# Dynamic Externalities in Denmark

## An Analysis of Danish Industry Structures & Regional Growth


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# Abstract

Theories on endogenous growth highlight that knowledge spillovers are crucial in promoting regional development. While the theories of Marshall-Arrow-Romer, Porter, Jacobs, and the Schumpeterian Growth Model agree on the importance of dynamic externalities, they differ in terms of what industry structures best ensure economic growth. Specifically, this controversy centers on the effects of industrial specialization, competition, and diversification. The purpose of this study is to investigate the relationship between the industry structure and regional growth in 29 Danish commuting zones from 2008 to 2019. Using data from Statistics Denmark, this paper applies commuting zone-industry employment as a proxy for regional growth in a fixed effects regression model.

The main finding of this paper is that local specialization and less fierce competition encourage employment growth in Danish commuting zone industries. This result suggests that knowledge spillovers occur within rather than across industries, consistent with the theories of Marshall-Arrow-Romer. On the basis of this analysis, three explicit recommendations are proposed for policymakers to ensure optimal growth opportunities for Danish regions.


**Keywords:** Externalities, knowledge spillovers, regional growth, employment, industry structure.

# Table of Contents

## List of Figures



## List of Graphs



## List of Tables

# 1. Introduction

Economic growth is one of the key elements in the memorandum of understanding signed by the Danish Social Democratic government and its supporting parties in 2019. In this memorandum, one of the top priorities is to create a *cohesive Denmark* with the right balance between the countryside and cities (Frederiksen et al., 2019). More specifically, the government want to challenge the recent wave of centralization by ensuring development and employment opportunities in the entire country, not just in the capital area of Copenhagen (Ibid.). To achieve this goal, Kaare Dybvad – the Minister of Interior and Housing – intends to improve and extend education outside large urban areas and to ensure better connectivity in terms of improved infrastructure (Nielsen, 2021). This work has resulted in the recently published infrastructure plan called *Denmark Forward*, which includes investments in infrastructure projects of DKK106 billion to improve the connectivity of the entire country and make Denmark grow richer (Transportministeriet, 2021).

In addition to infrastructure investments, the government will ensure development and employment opportunities by enabling cluster development (Uddannelses- og Forskningsministeriet, 2020). In this way, the Minister of Education and Research, Ane Halsboe-Jørgensen, seeks to increase collaboration between researchers and firms and, ultimately, increase the overall level of innovation in society (Ibid.). In line with the goal of a *cohesive Denmark*, Ane Halsboe-Jørgensen aims to enable cluster development in all regions of Denmark. Out of a total of 60 identified clusters in Denmark, 14 of them are placed in Copenhagen (Ibid.). Thus, the identified clusters are relatively well-distributed across the entire country. One example of such a cluster is the robotics cluster in Odense, which employed more than 8,500 people in 2019 and is expected to employ more than 25,000 people in 2025 (Pedersen, 2020). The robotics cluster in Odense emerged from a unique collaboration between firms and research institutions (RoboCluster, n.d.), which has reinforced its strong position in the robotics industry globally (Pedersen, 2020). The high concentration of robotic companies in Odense has helped the entire cluster to prosper and grow. This focus on collaboration and clustering is not merely a political concept, but also well-known in the literature on endogenous growth. Here, externalities – and knowledge spillovers, in particular – are perceived as the main drivers of innovation and, hence, economic growth (Romer, 1986).

In the context of dynamic externalities, a general debate exists among researchers concerning which industry structure is optimal to support regional growth. The controversy lies in the context of the theories on specialization and diversification as well as competition. On the one hand, the theory of Marshall-Arrow-Romer (MAR) externalities claims that knowledge spillovers are better enabled with a specialized industry structure and via monopoly competition. This theory is empirically supported by the findings of van der Panne (2004) and Song, Simons, and Wei (2019). On the other hand, Jacobs externalities assert that knowledge spillovers between a diverse set of industries and fierce competition stimulate economic growth. Here, Glaeser, Kallal, Scheinkman, and Schleifer's (1992) findings for the US labor market align with Jacobs' theory, along with several other papers (cf. Feldman & Audretsch, 1999; Frenken et al., 2007). Additionally, Porter's theory on knowledge spillovers contends that clusters of regionally specialized industries and local competition generate growth. Most papers, however, find mixed evidence of Porter's theory, as they instead tend to find evidence of competition but not specialization (cf. Glaeser et al., 1992; van Stel & Nieuwenhuijsen, 2002).

Some studies have further segmented the industries according to high- and low-tech sectors. Here, the studies generally find that Jacobs externalities are more prevalent among the high-tech industries, while the low-tech industries are characterized by MAR externalities, on average (Henderson et al., 1995; Paci & Usai, 1999). Accordingly, numerous researchers have examined the drivers of knowledge spillovers in terms of industry structures on regional growth. Yet, research within Scandinavian countries remains fairly scarce. Based on the contrasting theoretical views and the limited research of Denmark within this discipline, it is relevant to examine, if Danish regional industries have grown faster under industrial specialization or diversification, and if monopoly settings or competition stimulate regional growth. These considerations lead to the following research question:

> ***What is the relationship between the industry structure and regional growth in Denmark in the years following the financial crisis?***

This paper shows that industrial specialization and less fierce competition have enhanced regional growth in Denmark in the years after the global financial crisis. With a point of departure in the empirical literature, a quantitative method is applied to explore the drivers of regional employment growth operationalized by the key independent variables of specialization, competition, and diversification. Accordingly, the data is collected from Statistics Denmark on various components across industries and regions for the years spanning from 2008 to 2019. Guided by a number of created hypotheses, this paper focuses on 29 Danish regions, where the unit of analysis are the six largest industries within each commuting zone. To test these hypotheses optimally, several econometric tests determine that the most fitting regression is a fixed effects model with entity- and time fixed effects.

Analyzing the data, this study finds that MAR externalities are best capable of explaining employment growth across Danish regions. Here, specialization is positively and significantly associated with employment, whereas competition is negatively and significantly related to employment. Meanwhile, diversification is only positively and weakly significant in one out of four models. Additionally, the findings suggest that employment in both high- and low-tech industries are explained by MAR externalities, although specialization is more pronounced for the low-tech sector. As a result, the findings from the analysis support MAR externalities while providing mixed results for Jacobs and Porter's theories on dynamic externalities.

Based on this analysis, a discussion follows of why MAR externalities apply in a Danish setting. Specifically, it is suggested that the Danish welfare model and the specialized education system explain the findings of MAR externalities. Here, politicians are recommended to consider specialization effects when conducting employment policy, while business managers are advised to consider the advantages from knowledge spillovers and cluster effects when locating their businesses.

## 1.1. Delimitation

Due to the nature of the study, this project only focuses on Denmark and Danish regions. Further, it does not solely examine the larger metropolitan areas – such as Copenhagen and Aarhus – but it rather explores the Danish regions in general. In line with the academic literature base, this study does not try to determine the specific direction of causality. Instead, it examines the relationship between employment growth and industry structure in Denmark. Lastly, this paper does not investigate how firms or regions can increase productivity. Instead, it finds what industry structures are associated with regional employment growth and, by that, substantiate which policies can be implemented to facilitate this growth. Thus, this project applies employment as a proxy for regional growth rather than wages or patent citations.

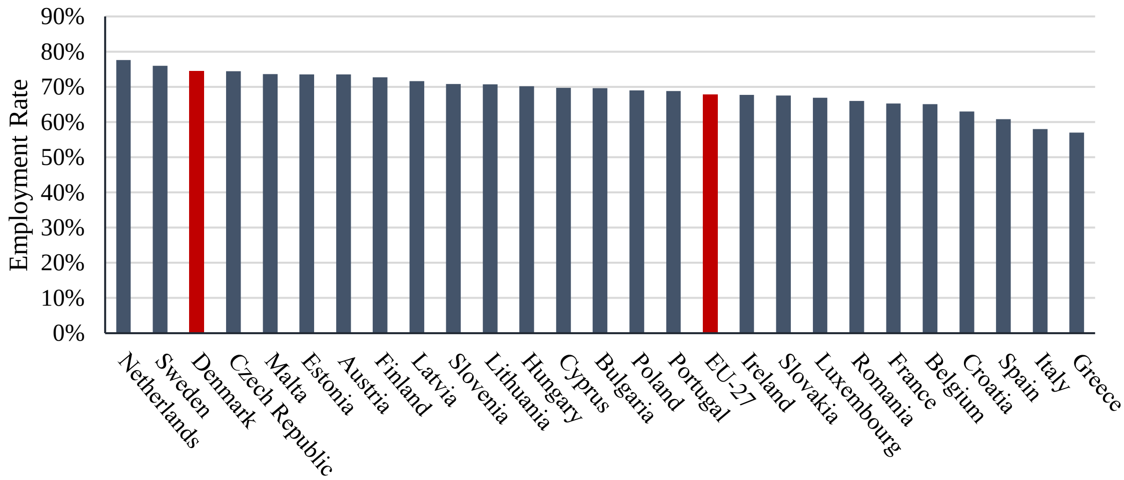
## 1.2. Structure of the Paper

To answer the aforementioned research question, this paper is structured in the following way. Section 2 provides some background information on the Danish welfare model, labor market, and industry structure. Section 3 outlines the theoretical and empirical literature on the subject and creates the foundation of the defined hypotheses. Section 4 presents the method applied in this study, including data sampling, variable operationalization, and the econometric model. Section 5 includes a presentation and analysis of the results obtained from regions overall as well as the high- and low-tech industries. Section 6 provides a discussion of the analysis and why these results are seen in a Danish context. Further, this section presents important implications for politicians and firm managers. Lastly, the study is concluded in Section 8 and includes considerations for future research as well.

# 2. The Danish Economy

In recent times, Denmark has experienced a relatively high employment rate compared to other European countries, as seen in Graph 1 (Danmarks Statistik, 2021). Considering the effects on the labor market of both the financial crisis and the ongoing Covid-19 pandemic, it is interesting to investigate how different regions in Denmark have tackled these issues and how their industry structures have supported employment.

**Graph 1**: Employment Rate in the EU (2020) for People in the Age of 15-64




**Source**: Author's creation with data from Danmarks Statistik (2021)

This section of the paper briefly outlines the general structure of the Danish economy to provide a better understanding of the mechanisms behind this relatively high employment rate. In relation to the research question, the section provides insights into where Denmark and its regions can support job creation.

## 2.1. The Danish Welfare State

The Danish economy is based on an institutional welfare model (hereafter, called the *universal welfare model*). This model is common in the Nordic European countries, and it addresses the entire population and embodies an institutionalized commitment to welfare (Esping-Andersen, 1990). Thus, the model is based on a strong state that redistributes part of the wealth from the richer citizens to the poorer ones. Furthermore, a universal welfare model provides many core services to its citizens for free – such as education, healthcare, and social security. However, to provide many of these services for free, the universal welfare model requires a relatively high and progressive tax level. Additionally, this system often results in a society with less inequality and is widely considered a more socialistic system (Ibid.).

In contrast, countries like the US and Great Britain apply a residual welfare model (Ibid.). This model is based on minimal state interference, in which it is the individual citizen's duty to secure their welfare through self-paid insurances. Only when there is no other alternative, the government provides minimal support for deserving social groups. The residual welfare model system usually has a relatively low tax level, creates more inequality than the universal welfare model, and is widely considered a more liberal system. Several countries in continental Europe apply a state-corporatist model (hereafter, called the *selective welfare model*) that is considered a mix between the other two extremes of welfare models. Here, employers and employees together take a bigger responsibility in ensuring overall welfare (Ibid.).

## Geographical Division

To answer the research question of this paper, it is central to understand the geographical division of Danish regions. Since the implementation of *Kommunalreformen* [the municipality reform] in 2007, the structure of the Danish public sector has been based upon five major regions and 98 municipalities, replacing the previous 14 *amter* [counties] and 277 municipalities (Indenrigs- og Sundhedsministeriet, 2005). The main goal of the reform was to improve the quality of the public sector by assigning these tasks to the local municipalities rather than at the country level (Ibid.). By decreasing the number of municipalities by almost two-thirds, the reform has transformed each municipality into larger areas with an average of 55,200 citizens, compared to 19,900 previously (Table 1). With this reform, the municipalities are required to take on more responsibility and a greater number of duties that are closely related to the citizens. For example, they are handling tasks related to health (rehabilitation), employment, public transport, and the social area, among others. The main task for the five regions is related to aspects concerning health, as the regions oversee the hospital system (Ibid.).

**Table 1**: Number of Residents in Municipalities in Selected European Countries

| | Below 1,000 | 1,000-5,000 | 5,001-10,000 | 10,001-50,000 | 50,001-100,000 | Above 100,000 | | |
|---|---|---|---|---|---|---|---|---|
| | Percent | | | | | | Total Amount | Average Size |
| Denmark 2005 | 0 | 5.9 | 41.7 | 46.1 | 4.8 | 1.5 | 271 | 19,900 |
| Denmark 2007 | 0 | 3.1 | 1 | 61.2 | 28.6 | 6.1 | 98 | 55,200 |
| Finland | 5.1 | 46.3 | 25 | 20.4 | 1.8 | 1.4 | 432 | 12,100 |
| France | 76 | 19 | 2.7 | 2.1 | 0.2 | 0.1 | 36,565 | 1,600 |
| Netherlands | 0.2 | 2.1 | 12.6 | 71.3 | 8.4 | 5.6 | 467 | 34,900 |
| Italy | 24.2 | 47.1 | 14.6 | 12.4 | 1.2 | 0 | 8,101 | 7,200 |
| Norway | 5.3 | 50.3 | 21 | 20.6 | 1.6 | 1.2 | 433 | 10,500 |
| Spain | 60.7 | 24.3 | 6.6 | 6.8 | 0.9 | 0.7 | 8,109 | 5,300 |
| Sweden | 0 | 4.5 | 21 | 59.7 | 10.7 | 4.1 | 290 | 31,100 |

**Source**: Indenrigs- og Sundhedsministeriet (2005)

Even though the Danish municipalities have become larger after the reform, many Danes are continuingly commuting across municipalities for work. For this reason, some municipalities are characterized by a high number of residents, while other municipalities have a larger number of workplaces. Because of this distortion, commuting zones have been created. A commuting zone is characterized by the fact that most people live and work in the same region (Thorsen et al., 2016). Since 1980, the number of commuting zones in Denmark has steadily decreased from 77 to 29 today. Hence, Danes have increased their willingness to commute longer distances to work over the past four decades. This is especially the case around the Copenhagen commuting zone – ranging from Roskilde to Helsingør – which is the largest commuting zone and comprises approximately one million workers (Ibid).

### The Flexicurity Model

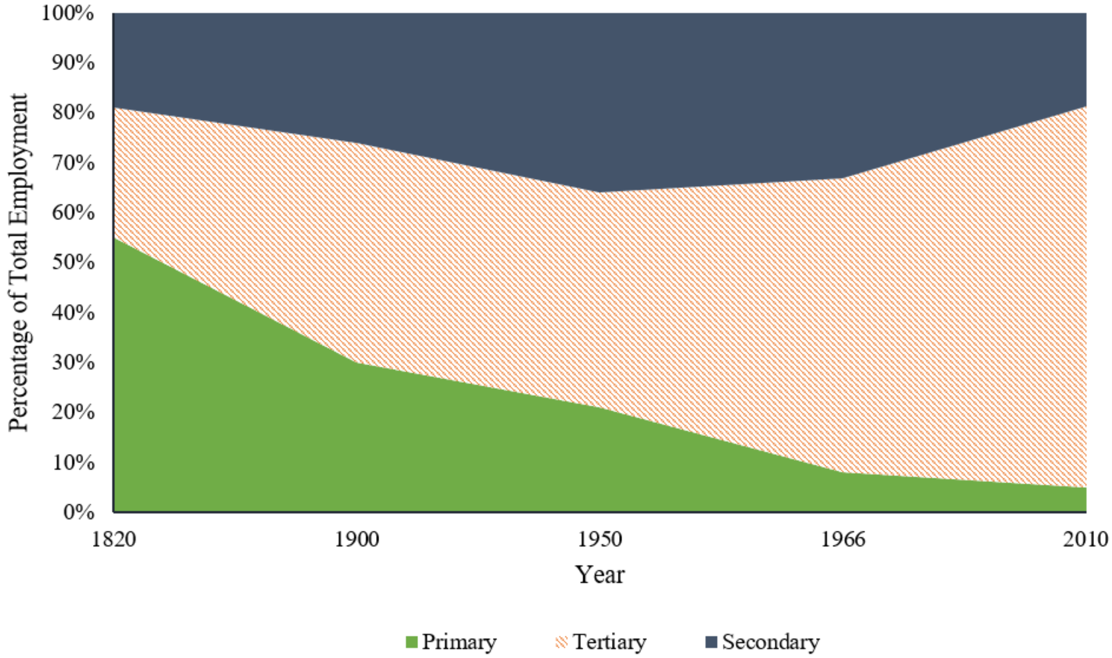
The Danish labor market is characterized by flexible and dynamic terms of employment. Meanwhile, it still keeps a high level of security for workers through a strong social safety net, indicating its name of *the Flexicurity Model* (Disruptionrådet, 2018). In this model, it is relatively easy for firms to hire and fire workers compared to other European countries and, thereby, it allows firms to post more vacancies. Simultaneously, unemployed workers enjoy the benefits of relatively high unemployment benefits, which enhance the individual’s income security and decrease the need for employment security. The final ingredient of the Danish model is the active employment policy ensuring that unemployed workers are available for firms looking for new hires. This policy is implemented through active work in job centers, helping unemployed workers either finding a new job or qualifying for new jobs – previously out of their skillset – through education (Ibid.).

In addition to the Flexicurity Model, coordinated market economies like Denmark “typically make extensive use of labor with high industry-specific or firm-specific skills,” where the labor market depends on workers with specialized skills developed through the education system (Hall & Soskice, 2001, p. 25). In the US, being classified as a liberal market economy, the educational system is more focused on providing workers with a general set of skills that fit with the fluid labor market, but “leaves some firms short of employees with highly specialized or company-specific skills” (Ibid., p. 30). Hence, the education system in Denmark is relatively more specialized than the education systems in the US, which arguably affects the employment mechanisms in both countries.

## 2.2. Industrial Pattern

Over the past two centuries, Denmark has moved from being a country primarily dominated by farmers – also called the primary sector – to be more and more dominated by services – that is, the tertiary sector (Graph 2). The importance of manufacturing industries – the secondary sector – increased during the first century, but they have steadily lost their jobs to the tertiary sector since 1950.

**Graph 2**: Industry Development in Denmark from 1820 to 2010




**Source:** Andersen, Bentzen, Nannerup, Smith, & Westergård-Nielsen (2016)

The shift from primary- and secondary industries to tertiary industries has been facilitated by a large increase in efficiency in farming and manufacturing in addition to an overall increase in wealth (Andersen et al., 2016). It has inevitably caused large shifts in industry structures around the entire country, especially in regions previously dominated by farming. Also, the factors of outsourcing and specialization have further contributed to the growing share of employment within the tertiary professions (Ibid.). This large shift in industry structure has demanded a high focus on education, which has ultimately fueled the urbanization trend evident today.

In relation to the growing tertiary sector, trade, social institutions, and education are the three sectors that employed the most people in Denmark in 2019 – employing 354,429, 315,153, and 213,683 workers, respectively (Table 2). Accordingly, the employment levels of these sectors emphasize the role of the public sector in the Danish economy. However, other industries have experienced the highest growth in the number of employees between

2008 and 2019. The hotels and restaurant industry has experienced the most rapid growth – with a 52% increase in the number of workers – followed by the pharmaceutical industry and the IT sector, which grew by 47% and 32.7%, respectively (Table 2). The substantial growth in the pharmaceutical industry is largely accredited to Novo Nordisk – manufacturer and marketer of insulin – and H. Lundbeck that produces psychopharmacological drugs. These two C25 companies are part of the *Life Science Cluster* in and around Copenhagen (Uddannelses- og Forskningsministeriet, 2020). The growth in hotels and restaurants is ascribed to the growing share of large international hotel chains locating in Denmark and an 8.6% annual increase in number of restaurants, bars, and cafés since 2008 (Andersen et al., 2016). The growth in IT and information services is seen in light of the growing demand for knowledge in the business community, thereby allowing favorable growth conditions for this industry (Ibid.).

**Table 2**: The Three Largest and Most Growing Industries

| Industry | Number of employees 2019 |
|---|---|
| Trade | 354,429 |
| Social Institutions | 315,153 |
| Education | 213,683 |

| Industry | Percentage growth since 2008 |
|---|---|
| Hotels and Restaurants | 52.0% |
| Pharmaceutical Industry | 47.0% |
| IT and Information Services | 32.7% |

**Source**: Danmarks Statistik (2020)

Whether or not Denmark has a relatively specialized or diversified workforce compared to its neighboring countries may influence Denmark's ability to generate knowledge spillovers within and across industries. These spillovers can subsequently affect Denmark's ability to create jobs in the future. Theories disagree on this matter, namely if it is better for job creation to have a specialized or a diversified workforce. These theories and academic findings are explored in the next section of the paper.

# 3. Literature Review

In this section, the predominant theories within the topic of dynamic externalities are presented. Afterwards, the most influential papers testing these theories are outlined to form the main hypotheses of this paper.

## 3.1. Theoretical Literature

In Glaeser and colleagues' (1992, p. 1127) paper, they examine the theories of dynamic externalities associated with knowledge spillovers – that is, "innovations and improvements occurring in one firm increase the productivity of the other firms without full compensation." With a similar theoretical background, this section of the paper serves as a point of departure in the theories of MAR, Jacobs, Porter, and the Schumpeterian Growth Model (SGM) concerning the market conditions that accommodate knowledge spillovers and engender regional growth.

### 3.1.1. Marshall-Arrow-Romer Externalities

The MAR externalities, originally coined by Glaeser and colleagues in 1992, are assembled by the theories advanced by Marshall, Arrow, and Romer. This theory suggests that economic growth is accelerated by a combination of a high concentration of firms operating within the same industry and by less fierce competition.

The origin of MAR externalities dates back to Alfred Marshall's work from 1890 on the concentration of industries in certain localities in book IV, chapter X. Herein, he details how employers gain from proximity to other firms in terms of idea generation and through sharing "workers with the special skill which they require" (Marshall, 2013, p. 225). Later, Kenneth Arrow (1962) expanded on this view of spillovers by specifying that employees will naturally think of ideas to improve production through experiences. Thereby, he proposed learning by doing as a source of increasing performance. In a similar vein, Paul Romer (1986; 1990) furthers the theory of endogenous growth through his work on increasing returns within the production of goods and stock of capital determining the growth rate.

As a result, MAR theorizes that monopoly allows for innovation and externalities to be internalized by the innovator. Alternatively, with competition, companies risk losing – or involuntarily sharing – their insights from R&D investments (i.e., knowledge) to other firms through imitation without full compensation to the originator of the idea. Thereby, according to MAR externalities, monopoly conditions enhance the innovation incentive for a firm, as monopoly conditions allow the firm to reap the full benefits of its R&D investments (Ibid.).

Moreover, MAR theory asserts that regions with specialized industries should be faster growing than those that are not specialized. This notion is partly attributable to the knowledge spillover resulting from the informal and formal exchanges of information among co-workers and neighboring firms' employees. To this effect, the regions in which these industries are situated will likewise grow relatively faster (Glaeser et al., 1992). This is exemplified by the knowledge spillovers apparent in the motion picture industry in Hollywood, where the proximity of specialists allows for "easier collaboration, experimentation, and shared learning among individuals and firms" (Carlino, 2001, p. 18). Accordingly, MAR theory hypothesizes that specialization of industries and monopoly competition will support regional growth.

### 3.1.2. Porter's View on Clusters and Competition

Similar to MAR, Michael Porter (1990, 1998) promotes the idea of regional specialization of industries to generate growth through his notion of clusters. Porter argues that firms within a cluster – that is, a "geographic concentration of interconnected companies (…) in a particular field" – can engender greater productivity, innovation, and competition than an industry scattered over several geographic areas (Porter, 1998, p. 78). This consequence is accredited to a regionally specialized industry having access to a great pool of skilled workers, suppliers, and information channels as well as proximity to research institutions and universities (Ibid.). Specifically, Porter argues that these factors benefit the rate of introduction of new technology and increased human capital.

While Porter's idea of clusters is similar to MAR, his view on competition opposes MAR. According to Porter, rivalries and competition enhance the demand for products while encouraging the formation of supporting industries. Competition underpins growth within a city or region, as local rivalry amplifies competition and imitation, which further motivates innovation and improved products (Ibid.). As a result, the competitive forces pressure companies to stay innovative to beat the rivals, whereby these companies generate more externalities for the local economy. Hence, Porter argues that fierce competition – rather than monopoly – and geographically specialized industries foster economic growth.

### 3.1.3. Jacobs Externalities

In line with Porter, Jane Jacobs (1969) argues that competition is the market structure that provides the most incentive for investing in innovation. Rather than a monopoly structure, Jacobs infers that competition increases the rate of innovation with new processes of production and products since companies are at constant risk of imitation, similar to Porter's logic (Carlino, 2001). Specifically, Jacobs considers monopolies as disadvantages to cities and their potential, as "monopolies forestall alternate methods, products, [and] services" (Jacobs 1984, cited in Glaeser et al., 1992, p. 1132).

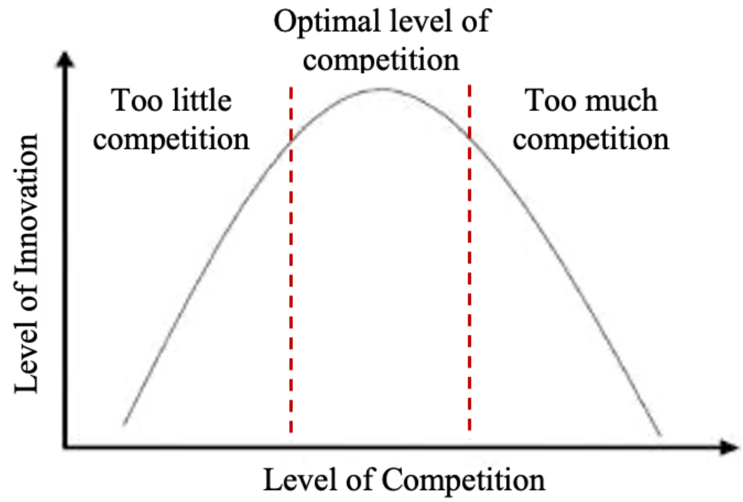
Contrary to both MAR externalities and Porter's theory, Jacobs believes that diversity of industries will support economic growth. She bases her argument on "the greater the sheer number of and variety of labour, the greater the economy's inherent capacity for adding still more kinds of good and services" (Jacobs 1969, p. 59). As a result, knowledge spillovers are more likely to arise from outside specific industries and through a variety and mix of people's backgrounds that encourage the development of novel ideas and products (Carlino, 2001). These novelties originate through interactions among people from different professions and varying skills, needs, and tastes within diversified environments (Jacobs, 1969; Glaeser et al., 1992). In connection with Jacobs, Carlino (2001) points out that the gasoline engine – used in cars – derived from the boat engine industry rather than the automobile industry. Thus, Jacobs predicts that local competition and diversification of business sectors are the optimal market conditions for engendering regional economic growth.

### 3.1.4. The Schumpeterian Growth Model

In contrast to Jacobs and Porter, but in support of MAR, Joseph Schumpeter (2010) promotes the idea of monopolistic competition. While monopoly prices are typically higher and aggregate output is typically lower than with perfect competition, Schumpeter claims that "there are superior methods available to the monopolist which either are not available at all to a crowd of competitors or are not available to them so readily" (Schumpeter, 2010, p. 87). These arguments accord to Schumpeter's novel thoughts on innovation, since he believes that long-run growth results from innovations. Schumpeter calls this innovation process *creative destruction*, which he defines as "the process by which new innovations replace older technologies" (Aghion et al., 2015, p. 558).

Based on the developments in organizational theory and on Schumpeter's thoughts of creative destruction, Aghion, Akcigit, and Howitt (2015) present an alternative model of endogenous growth called the SGM. This model is linked to Schumpeter's thoughts since "(i) it is about growth generated by innovations; (ii) innovations result from entrepreneurial investments that are themselves motivated by the prospects of monopoly rents; and (iii) new innovations replace old technologies: in other words, growth involves creative destruction" (Aghion et al., 2015, p. 558). In the SGM, an increase in competition is expected to have an ambiguous effect on growth. The effect will thus depend on the fraction of 'neck-and-neck' sectors versus the fraction of 'unleveled' ones, since these two kinds of sectors respond differently to competition. In 'neck-and-neck' sectors, more competition induces firms to innovate to escape competition and to acquire a lead over their rivals. In 'unleveled' sectors, the laggard firms are less motivated to innovate when facing competition, since they are more inclined to focus on short-term profits. The relative share of these two sectors creates an inverted-U shape relationship, where an optimal level of competition is found somewhere between the two extremes of perfect competition and monopoly competition (Graph 3).

**Graph 3**: The Inverted-U Relationship of Competition and Innovation




**Source**: Author's creation

In relation to the other theories, the SGM has no significant predictions for specialization or diversification. Still, the SGM can prove useful for politicians when designing economic growth policy and adjusting the role of the state, as policies must adapt to current institutions and the level of technology (Aghion & Festré, 2017).

### 3.1.5. Theories on Dynamic Externalities

In sum, all the authors above agree that knowledge spillovers are vital ingredients for generating economic growth along with prosperous cities and regions. Beyond the importance of externalities, however, the authors offer different notions of what market conditions encourage these knowledge spillovers the most. Here, Porter and Jacobs promote competition as the preferable market condition for regional growth, while MAR argues that monopoly within an industry promotes regional growth. Within the spectrum of geographical specialization and diversification of industries, MAR and Porter favor the former, while Jacobs argues that industrial diversification is the most optimal way to ensure regional growth (Table 3).

Given these contrasting views on the vehicles of knowledge spillovers, it is interesting to investigate whether the Danish regional industries grow faster under geographic specialization or diversification and monopoly conditions or competition. Additionally, it is interesting to take a more granular look at which regions that thrive under certain industry structures with relation to the high- and low-tech sectors.

**Table 3**: Theoretical Predictions

| Theory | Specialization | Competition | Diversification |
|---|---|---|---|
| **MAR** | + | – | 0 |
| **Porter** | + | + | 0 |
| **Jacobs** | 0 | + | + |
| **SGM** | 0 | + / – | 0 |

**Source**: Author's creation

These theories have been widely tested in several regions around the world. The next section of the paper outlines the predominant papers examining these theories in different geographical areas during different time periods.

## 3.2. Empirical Literature

Overall, the literature on MAR, Porter, and Jacobs' theories on dynamic externalities has reached mixed results. Some papers have found evidence supporting Jacobs, while others have found evidence confirming MAR or Porter's theories. However, the majority of the reviewed papers have found a positive and significant effect of diversification and competition on employment growth. Moreover, there is a larger tendency to find a negative correlation between specialization and employment growth (cf. Glaeser et al., 1992). Accordingly, this literature has established the basis for the formulation of this study's hypotheses on growth in commuting zone-industries (CZ-industries):

*Hypothesis 1 (H1):* *More specialization of CZ-industries is negatively associated with regional employment growth.*

*Hypothesis 2 (H2):* *Fiercer competition within CZ-industries is positively associated with regional employment growth.*

*Hypothesis 3 (H3):* *More diversification of CZ-industries is positively associated with regional employment growth.*

*Hypothesis 4 (H4):* *High-tech industries experience higher employment growth in regions with more diversification of CZ-industries.*

*Hypothesis 5 (H5):* *Low-tech industries experience higher employment growth in regions with more specialization of CZ-industries.*

The following section of the paper outlines the most influential literature written on the topic of dynamic externalities. The empirical literature has been collected from a variety of academic journals and books. The purpose of this review is to guide this paper's choice of method and econometric model. Moreover, this section aims to form the basis for a discussion of the results concerning externalities in Danish regions. Since the majority of the academic literature written within this discipline has focused on the United States (US), this is a natural starting point for reviewing the literature.

### 3.2.1. Evidence from the United States

Research on knowledge spillovers and dynamic externalities has its origin in the US, which is also the most intensely studied region. In 1992, Glaeser and colleagues made the first empirical test of the three economic growth theories, where they investigated which industries – in which cities – grew the fastest between 1956 and 1987, and why that was the case. They argue that these theories of dynamic externalities are important, since these theories simultaneously try to explain why cities form and how they grow. The authors analyze a cross-section of city-industries and find that employment grows faster in cities with a more diverse and competitive industry structure rather than with a more specialized and monopolistic structure. Hence, according to their findings, the most important knowledge spillovers occur in a competitive and diversified industry structure, in line with hypotheses H2 and H3. Additionally, Glaeser and colleagues (1992) conclude that industrial specialization has harmed employment growth, in accordance with hypothesis H1. These findings are consistent with Jacobs externalities, displays mixed support of Porter's theory, and rejects the existence of MAR externalities.

With Krugman's argument that knowledge flows in themselves leave a very little paper trail and are in fact invisible, it can be difficult to precisely estimate the effect and extent of specific knowledge spillovers (Jaffe et al., 1993). However, knowledge flows do sometimes leave a paper trail in the form of patent citations. Thus, using a patent citation approach, Jaffe, Trajtenberg, and Henderson (1993) find that domestic patents are more likely to be cited domestically and more likely to originate from the same state and Standard Metropolitan Statistical Area (SMSA) as the cited patents. This effect is particularly strong at the SMSA level, indicating strong localization effects of patent citations. The effect, however, fades slowly over time, indicating that the knowledge eventually will spread outside the otherwise bounded geographical area. In a similar vein, Song and colleagues (2019) find evidence of MAR externalities by also using a patent citation approach.

Henderson, Kuncoro, and Turner (1995) find evidence of both MAR- and Jacobs externalities from 1970 to 1987. However, they distinguish between mature capital goods industries and new high-tech industries and find that MAR externalities are prevalent in mature industries, similar to H5, while Jacobs externalities are prevalent in newer high-tech industries, similar to H4. In particular, they find that Jacobs externalities are important in attracting new industries, while MAR externalities are important in retaining them.

Similar to Glaeser and colleagues (1992), Feldman and Audretsch (1999) also find considerable evidence of Jacobs externalities but little support for MAR externalities. In addition, they also find that local competition within a city is more productive for innovation than a local monopoly is, which again underpins Jacobs externalities and partly supports Porter's theory. Nonetheless, their method differs from Glaeser and colleagues' (1992), as they test their results on both industry- and firm-level, and find that the results hold for both levels, indicating the robustness of their findings.

On a more recent note, Kemeny and Storper (2015) find a positive relationship between absolute specialization and wages, indicating a positive effect of specialization on economic growth. Thus, their results reflect the existence of MAR externalities and Porter's theory, but without analyzing competition, however. They do not find any significant relationships between relative specialization and wages.

### 3.2.2. Evidence from Europe

Similar to the research related to the US economy, several studies have investigated the impact of knowledge spillovers on regional growth on the European continent. In this respect, the results of dynamic externalities within European countries are mixed, although the literature primarily supports Jacobs.

A number of studies confirm the findings of Glaeser and colleagues (1992) by evidence of Jacobs externalities enhancing regional growth (cf. Bishop & Gripaios, 2010; Boschma et al., 2011; Frenken et al., 2007; van Stel & Nieuwenhuijsen, 2002). In the replicating study of Glaeser and colleagues (1992), van Stel and Nieuwenhuijsen (2002, p. 402) retrieve similar results for 40 Dutch regions from 1987 to 1995, as "higher degrees of regional diversity generate higher spillovers and, therefore, higher growth rates." Moreover, local competition is found to increase the innovativeness in line with Porter's and Jacobs' arguments. Furthermore, Bishop and Gripaios (2010) find that specialization impairs regional growth in their study of British regions. Besides this finding's resemblance to the conclusion of Glaeser and colleagues from 1992, it further supports the expectation reflected in hypothesis H1. In Frenken, von Oort, and Verburg's (2007, p. 687) study of regional knowledge spillovers in the Netherlands, the authors find that Jacobs externalities enhance employment growth, suggesting that these spur "radical innovation and product innovation" through the combination of different industry knowledge. Accordingly, hypothesis H2 and H3 are further substantiated by the findings of Frenken and colleagues (2007). Boschma, Minondo, and Navarro (2011) reach a similar conclusion for 50 Spanish provinces in terms of value-added regional growth. Moreover, Boschma and colleagues (2011) do not discover a relationship between unrelated variety –

which captures the regions' resilience to external shocks through having several unrelated industries – and regional growth. Contrarily, Frenken and colleagues (2007) observe that an unrelated variety of industries dampens unemployment growth and, thus, diminish the regions' sensitivity to severe external shocks.

Additionally, other papers have provided evidence in support of both MAR- and Jacobs externalities (Greunz, 2003; Paci & Usai, 1999). Testing the externalities via a dependent variable of patent applications, in line with Jaffe and colleagues (1993), these studies find evidence of Jacobs externalities being more pronounced in high-tech industries and metropolitan or high-density areas, in line with previous studies (cf. Henderson et al., 1995). In Paci and Usai's (1999) paper, the researchers conclude that both types of externalities have a positive effect on regional innovativeness in Italy. Greunz (2003) remarks that his findings on European regions suggest that regions with industrial diversity are more likely to attract new industries from high-tech industries. Finding evidence of both externalities may sound contradictory, but van der Panne (2004, p. 599) interprets this complexity as "a diversified region may also accommodate the larger part of a particular industry." Hence, some sort of specialization can exist within an otherwise diversified region.

Specifically, van der Panne (2004) finds evidence in support of MAR rather than Jacobs and Porter in his study of 98 Dutch regions. In contrast to other studies on the Netherlands, his panel regression finds that 'within sector' – rather than 'between sector' – knowledge spillovers explain regional innovativeness. Interestingly, his results suggest that monopoly competition within one industry strengthens innovative endeavors, since larger firms have greater "means to engage in R&D and exploit economies of scale and scope" (van der Panne, 2004, p. 602). Notably, van der Panne (2004) remarks that one reason for non-significant results concerning diversification might indicate that there are no marked differences in terms of industrial diversification between the regions.

With these mixed findings of dynamic externalities on both an American and European level, it is central for this paper to investigate what researchers have found in a Nordic European context. Here, the governments' capacities are more alike the Danish one and, hence, the findings are also of great relevance to the aim of this paper.

### 3.2.3. Evidence from Northern Europe

The amount of literature on knowledge spillovers and dynamic externalities in Northern Europe is relatively scarce, which makes research within this area even more important. Nonetheless, some studies have been conducted, in which the most dominant are outlined below.

Jespersen (2003) tests whether regional economic specialization or diversification leads to positive externalities between firms and, ultimately, increased productivity growth in the regions. Controlling for educational level and worker experience, he finds that neither specialization nor diversification have any significant effect on productivity growth. He does find, however, that human capital gives rise to significant positive externalities, which emphasizes the importance of education. In addition, he argues that competition has an ambiguous effect on innovation, consistent with the SGM. With these results, Jespersen (2003) argues that employment policy should neither promote specialization nor diversification for specific regions. Rather it should aim at educating non-skilled workers and increase geographical mobility of the workforce, since this would have the strongest positive effect on employment growth. Here, Monsson (2014) generally agrees and elaborates that non-metropolitan areas may not benefit from specialization nor cluster formation to the same degree as metropolitan areas. Instead, he argues that non-metropolitan areas can benefit from alternative models of knowledge creation matched to the needs of local companies and based on the regional strengths and challenges. In a similar vein, Simonen, Svento, and Juutinen (2015) analyze the relationship between regional industrial structure and economic growth. By focusing specifically on high-tech sectors, they find evidence of diminishing marginal returns to diversification and specialization. Thus, an increase in specialization or diversification will have the strongest employment effect for regions not already heavily specialized or diversified, respectively.

Using a slightly different method, Neffke, Henning, and Boschma (2011) test whether 70 regions in Sweden experienced technological relatedness between 1969 and 2002. They find that regions in Sweden are strongly path dependent. In other words, regions tend to branch out into industries that are technologically related to the already existing industries in that region. Firms in industries that are technologically related have a higher probability of entering a region, and firms in non-related industries have a higher probability of leaving that region, all else equal. Thus, Neffke and colleagues (2011) argue that regions should not just diversify for the sake of diversification, but they should diversify into technologically related industries to reach the optimal industry structure for economic growth. In that sense, they argue for something between MAR- and Jacobs externalities, with a focus on diversification and relatedness.

Even though Sweden might be considered rather similar to Denmark one of all the countries analyzed, there are still marked differences. Eriksson, Hansen, and Winther (2017) demonstrate that the two countries react relatively similarly to changes in employment on an aggregate level. But when analyzing the changes on a regional industry level, however, regions react differently to changes in employment, suggesting that the context matters concerning the size and characteristics of regions. These results highlight the importance of a study on the Danish economy related to regional growth and to generate policy recommendations specifically for the Danish regions.

## 3.3. Sub-Conclusion

In sum, there is consensus among the theorists that dynamic externalities are imperative in explaining regional growth. However, the vehicles of these externalities differ among the authors. MAR and Porter argue that industrial specialization favors regional growth, while Jacobs holds that diversification of industries strengthens knowledge spillovers. Additionally, Jacobs and Porter claim that fierce competition promotes regional growth, while MAR states that monopoly conditions increase the incentive to innovate and, thereby, induce regional growth. Here, SGM argues that competition has an ambiguous effect.

Overall, the literature written on the topic of dynamic externalities has reached mixed results by providing evidence of both MAR- and Jacobs externalities, as well as supporting Porter's theory on competition. However, it seems that most papers have found positive effects of diversification and competition, which is also reflected in the hypotheses developed in this paper. Moreover, several studies have found a significant relationship between high-tech industries and diversification as well as low-tech industries and specialization on regional growth. The hypotheses developed in this section are now tested on Danish regions to investigate the relationships in a Danish context. The method in doing so is outlined in the following section of the paper.

# 4. Method

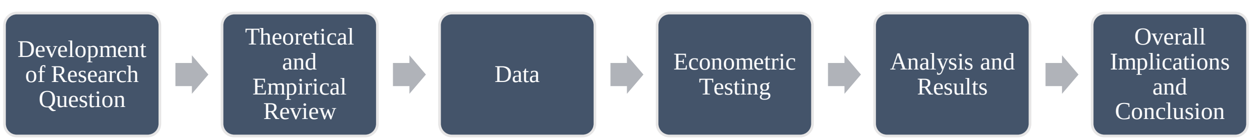
As Glaeser and colleagues (1992, p. 1140) argue:

> *If externalities are important for growth, then the clearest way to find these effects is by looking at the growth of the same sectors in different cities and checking in which cities these sectors grow faster.*

Accordingly, this paper analyzes industry structures in Danish commuting zones to detect what fosters regional employment growth in Denmark.

The methods applied in data collection, choice of variables, analysis, and discussion of the results are outlined in the following section. A quantitative method is used to analyze the data, consistent with the presented literature. The quantitative method allows for large amounts of data and for some generalizations across geographical areas, which is highly relevant for policymakers concerning employment policy. The main drawback is the lack of detailed insights on local knowledge, which might be gathered through a qualitative method. However, due to the time constraints of this study and the general nature of employment data, it is argued that the quantitative method is the best possible method for this study. Thus, it results in the following research design:

**Figure 1**: Quantitative Research Design




**Source**: Author's creation

By application of the research design in Figure 1, the following regression model is formulated:

$$\begin{aligned} Employment\ growth_{it} &= \beta_1 Specialization_{it} + \beta_2 Competition_{it} + \beta_3 Diversification_{it} + \beta_k Controls_{it} \\ &+ \mu_i^{Commuting\ zones} + \lambda_t^{Year} + v_{it} \end{aligned} \quad (1)$$

This regression model is applied to the 11-industry data set, while the competition variable is omitted in the 37-industry data set. Next, the data collected, the econometric process of generating the regression equation, and the chosen variables are presented with a point of departure in this paper's philosophy of science.

## 4.1. Philosophy of Science

Overall, this study operates within the ontological sphere of realism, where the theory of knowledge is studied through the lens of a positivist epistemology. In this sense, reality is viewed as objective and external to the observer, where research intends to examine whether the chosen theories explain reality (Easterby-Smith et al., 2015). With this inherently deductive reasoning, the paper seeks to find explanations of which dynamic externalities – conceptualized by theories – are at play within Denmark. This is conducted to further substantiate the findings of existing literature, in line with a positivist epistemology. To this effect, the research approach corresponds to Karl Popper's (2002) scientific method through the assumption of observer independence, defining measurable terms, and using large data samples. Consistent with the scientific method, this study recognizes that the theories and hypotheses cannot be 'proved' or 'confirmed' but rather falsified. The hypotheses are tested on quantitative data through panel regression analysis to disprove or refuse the hypotheses and form the basis for more general policy recommendations.

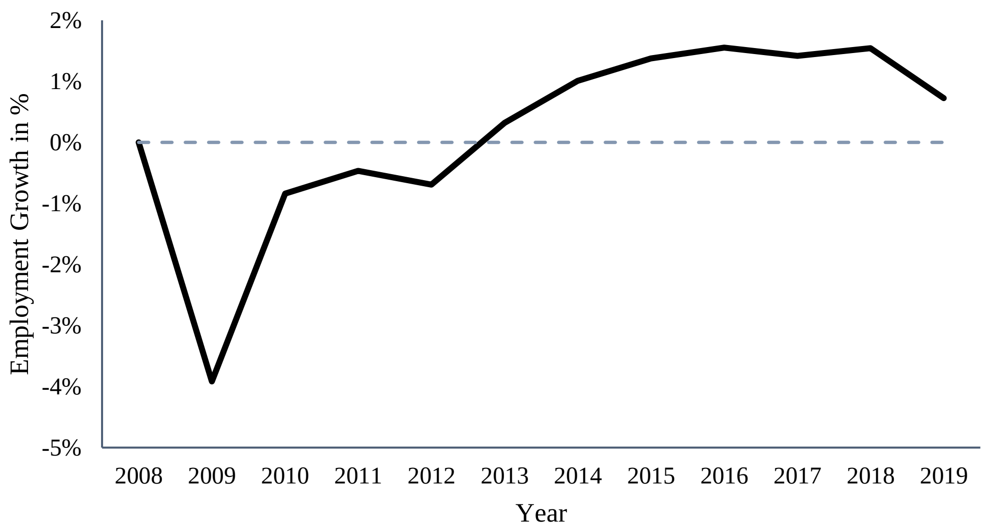
## 4.2. Rationale

In line with the ontological and epistemological considerations, this study applies a predictive research design to test the hypotheses and theories presented. While the paper builds on previous empirical work, the novelty centers around the focus on the post-financial crisis period of Denmark, in which limited attention has revolved around the influence of dynamic externalities on regional growth. Here, the ongoing discussion concerns where government spending should be targeted to enhance economic growth. Roughly, this issue can be narrowed down to whether spending should be targeted at larger metropolitan areas such as Copenhagen – which has grown considerably during the last decade, partially due to urbanization – or if the spending should be targeted at more struggling regions such as Nakskov – which has seen 18% of employment in 2008 disappear in 2019 (Table 4 and 5). Accordingly, the significance of this thesis is attributed to supplementing the understanding of what drives employment growth at a regional level and where regional heterogeneity might encourage tailormade policies to metropolitan areas. By extension, this study aims to test the existing theories of MAR, Porter, Jacobs, and SGM on regional growth within a Danish context. As a result, this paper addresses the main knowledge gap of research by focusing on the drivers of growth at a regional level in Denmark.

## 4.3. Data Collection

The data set is constructed using secondary data from Statistics Denmark between 2008 and 2019, which is considered a reliable and objective source. This period has been chosen, since it reflects the period following the financial crisis. Further, the data contains all years after the implementation of the municipality reform, which took effect in 2007. The data set contains 12 different years of data after the financial crisis.

**Graph 4**: Employment Growth in Denmark from 2008 to 2019




**Source**: Author's creation

As evident from Graph 4, the data set includes a large decrease in overall employment after the financial crisis from 2008 to 2012, while experiencing an increase in employment from 2013 to 2019. Hence, the data is well-diversified in terms of cyclical economic fluctuations. Furthermore, the post-crisis period is rather understudied compared to pre-crisis years, creating a knowledge gap that makes this period especially important to analyze.

The longitudinal data set contains information on CZ-industry employment, education, average income, number of residents, and national industry employment. Specifically, the information on employment and education has been confined to the ages of 20 to 64 to aim the findings at the Danish working-age population (cf. Eriksson et al. 2017). This exclusion is justified by the fact that young people below 20 are primarily students with part-time jobs (Skaksen, 2019), whereas the majority of people older than 64 have already retired from the labor market (Seniortænketanken, 2019).

All data is measured at a commuting zone level, following Statistics Denmark's definition of commuting zones, which results in data on 29 different geographical working areas of Denmark (Appendix 1). Christiansø has been omitted from this data set, since it is not formally a Danish municipality but instead administered by the Danish Ministry of Defense (Christiansø Administration, 2019). In line with previous literature, this paper focuses on a commuting zone level rather than municipalities or regions. The main advantage of using commuting zones is that people then live and work within the same area. Hence, it is less likely that one person counts as a resident in one area and as a worker in another area. This reasoning is especially relevant to the area of Copenhagen, which includes numerous municipalities in its commuting zone. Nonetheless, robustness checks are carried out with more detailed geographical areas to ensure the reliability and validity of the final results.

In line with previous studies (cf. Glaeser et al., 1992; Henderson et al., 1995; Bishop & Gripaios, 2010), industry-level employment is split based on one- and two-digit NACE codes according to the division made by Statistics Denmark. This split results in 37 different industries for all 29 commuting zones. When including the competition variable in the regression, however, employment is aggregated to 11 different industries due to the lack of firm data from Statistics Denmark. Both the 37- and the 11-industry data sets are included in the analysis. These industry groupings can be found in Appendix 2.

For each commuting zone, only the six largest industries measured on employment in 2008 are used in the analysis, since the focus of the paper is to investigate the relationship between the industry structure and regional growth in Denmark. Thus, this results in 174 different CZ-industries (29 commuting zones · 6 industries = 174 CZ-industries) for the analysis, which ultimately results in a total of 2,088 observations (174 CZ-industries · 12 years = 2,088 observations) for the 37-industry data set. The fact that only the largest industries are included creates a possible selection bias against young and dynamic industries that have not climbed into the top-six of a specific region yet. However, the theories being tested in this paper do not "just apply to industries in the early years of the product life cycle" (Glaeser et al., 1992, p. 1135). Further, it is argued that the six largest industries in a specific region constitute the largest share of the initial industry structure, which is the center of interest to this paper. It is, thus, consistent with the literature base and the overall scope of this study.

## High-Tech and Low-Tech

Aside from the general case, an analysis is also carried out specifically for high- and low-tech manufacturing industries together with service industries. The split of industries is based on the definitions established by Eurostat from 2020 (Appendix 3). While several previous papers have only focused on manufacturing industries within this segmentation (cf. Henderson et al., 1995; Paci & Usai, 1999; van der Panne, 2004), this paper applies knowledge-intensive and less knowledge-intensive service industries as well, given the predominance of the service sector with respect to employment (Graph 2). Here, the three commuting zones of Ærø, Tønder, and Aabenraa have been excluded, due to missing values in one or more of these high- and low-tech industries. This specific analysis aims to investigate whether different relationships hold for regions specialized in high-tech / knowledge-intensive industries[1] (referred to as *high-tech*) relative to regions specialized in low-tech / less knowledge-intensive industries (referred to as *low-tech*). This line of investigation is further motivated by the question of whether different economic theories hold for different kinds of industries.

### Descriptive Data

The following tables display the five largest and the five smallest commuting zones (based on employment in 2008), the growth in employment over the sample period, and the three largest industries in each commuting zone. Note that the largest commuting zone, Copenhagen, employed nearly 900,000 people in 2008, whereas the smallest commuting zone, Ærø, only employed 2,571 people. These levels of employment emphasize the large differences in size and density between commuting zones in Denmark.

**Table 4**: The Five Largest Commuting Zones Based on Total Employment in 2008

| | Employment | | | |
|---|---|---|---|---|
| Commuting Zone | 2008 | 2019 | %-Growth | Three Largest Industries |
| *Five Largest Commuting Zones in 2008* | | | | |
| København | 896,153 | 978,701 | 9% | 1) Trade<br>2) Social Institutions<br>3) Education |
| Aarhus | 246,646 | 267,317 | 8% | 1) Trade<br>2) Social Institutions<br>3) Education |
| Aalborg | 173,263 | 174,927 | 1% | 1) Social Institutions<br>2) Trade<br>3) Education |
| Odense | 162,797 | 161,596 | -1% | 1) Trade<br>2) Social Institutions<br>3) Education |
| Slagelse and Holbæk | 130,531 | 125,529 | -4% | 1) Social Institutions<br>2) Trade<br>3) Building and Construction |

**Source**: See Appendix 2 & 18 for industry classifications.

[1] Here, other knowledge-intensive services are excluded from the segment of high-tech industries.

**Table 5**: The Five Smallest Commuting Zones Based on Total Employment in 2008

| | Employment | | | |
|---|---|---|---|---|
| Commuting Zone | 2008 | 2019 | %-Growth | Three Largest Industries |
| *Five Smallest Commuting Zones in 2008* | | | | |
| Ærø | 2,571 | 2,057 | -20% | 1) Social Institutions<br>2) Education<br>3) Trade |
| Lemvig | 9,690 | 8,270 | -15% | 1) Social Institutions<br>2) Trade<br>3) Agriculture, Forestry, and Fishing |
| Bornholm | 16,799 | 14,866 | -11% | 1) Social Institutions<br>2) Trade<br>3) Education |
| Tønder | 17,407 | 15,033 | -14% | 1) Trade<br>2) Social Institutions<br>3) Education |
| Nakskov | 18,306 | 14,276 | -22% | 1) Social Institutions<br>2) Trade<br>3) Education |

**Note**: See Appendix 2 & 18 for industry classifications.

**Table 6**: The Ten Largest CZ-industries Based on Employment in 2008

| | Employment | | | |
|---|---|---|---|---|
| Commuting Zone | 2008 | 2019 | %-Growth | Industry |
| *Ten Largest CZ-industries* | | | | |
| København | 128,736 | 136,735 | 6% | Trade |
| København | 105,254 | 108,443 | 3% | Social Institutions |
| København | 70,060 | 79,905 | 14% | Education |
| København | 60,403 | 63,176 | 5% | Public Administration, Defense, and Police |
| København | 59,344 | 66,677 | 12% | Healthcare |
| København | 56,327 | 50,220 | -11% | Transportation |
| København | 53,346 | 66,895 | 25% | Travel Agencies, Cleaning, and Other Operational Services |
| København | 53,165 | 56,748 | 7% | Building and Construction |
| København | 48,930 | 49,826 | 2% | Finance and Insurance |
| København | 47,233 | 59,653 | 26% | Consulting etc. |

**Note**: See Appendix 2 & 18 for industry classifications.

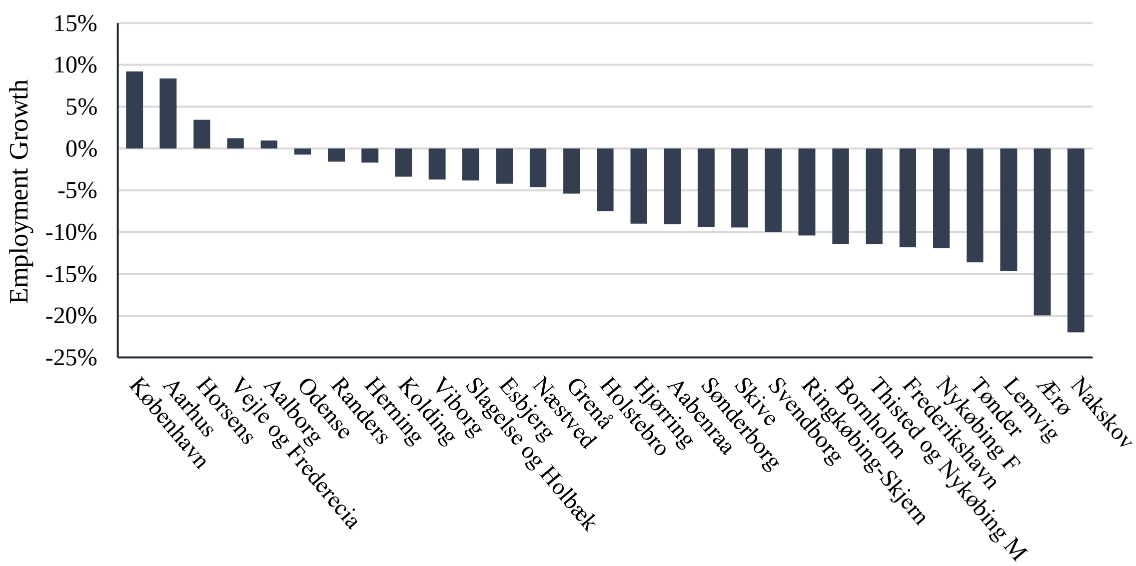
**Table 7**: Most Common CZ-Industries

| Industry | Number of Appearances in Sample |
|---|---|
| Trade | 29 |
| Social Institutions | 29 |
| Education | 28 |
| Building and Construction | 27 |
| Healthcare | 18 |
| Public Administration, Defense, and Police | 10 |
| Transportation | 10 |

**Note**: This table indicates the number of times these seven industries appear in the top six industries in the 37-industries data set. See Appendix 2 & 18 for industry classifications.

It is clear from Tables 4 and 6 that Copenhagen is the largest commuting zone. Especially since all the ten largest CZ-industries are located in Copenhagen. In addition, employment in Copenhagen and Aarhus has grown substantially over the sample period, even compared to the other large commuting zones such as Aalborg and Odense. From Table 6, it is evident that growth in employment in Copenhagen is mainly driven by part of the public sector (education and healthcare), trade, travel agencies, and consulting firms, while the transportation sector has decreased significantly. The smallest commuting zones, however, are dominated by islands and other less populated areas (Table 5), which have all experienced a large decrease in employment ranging from -11% to -22% over the sample period. These growth trends are further evident in Graph 5.

**Graph 5**: Employment Growth in All Commuting Zones (2008-2019)




**Source**: Author's creation with data from Danmarks Statistik (2021)

To measure which industries in which commuting zones have grown the most in the sample period, it is necessary to find the variables that proxy this economic growth the best. Besides, it is also imperative to determine which variables are to control for differences between the commuting zones. The exact choice of variables and what these bring to the analysis are discussed in the next section of the paper.

## 4.4. Choice of Variables

Table 8 below specifies the dependent-, key independent-, and control variables employed in the regression models. Specifically, these variable operationalizations are drawn from a variety of empirical papers such as Glaeser and colleagues (1992), Henderson and associates (1995), and Frenken and colleagues (2007).

**Table 8**: Variable Operationalization (2008 to 2019)

| Variables | Years | Description |
|---|---|---|
| *Dependent variable* | | |
| CZ-industry Employment | 2008-2019 | Log of employment per CZ-industry |
| *Key independent variables* | | |
| Specialization | 2008-2019 | Ratio of CZ-industry employment relative to the national level |
| Competition | 2008-2019 | Ratio of number of companies per worker within a CZ-industry relative to the national level |
| Diversification | 2008-2019 | Ratio of employment in the other five large CZ-industries relative to total employment that specific commuting zone |
| *Control variables* | | |
| Education | 2008-2019 | Log of number of people with at least a bachelor's degree per commuting zone |
| Residents | 2008-2019 | Log of number of residents per commuting zone |
| Average Income per Resident | 2008-2019 | Log of total income of the commuting zone divided by the number of residents of the commuting zone |
| National Industry Employment | 2008-2019 | Log of number of employees in the CZ-industry at a national level |

**Table 9**: Descriptive Statistics for the 37-Industry Data Set (2008 to 2019)

| Variables | Minimum | Median | Mean | Maximum | Std. Dev. |
|---|---|---|---|---|---|
| *Dependent variable* | | | | | |
| CZ-industry Employment (log) | 4.1271 | 8.0610 | 8.1580 | 11.8291 | 1.1727 |
| *Key independent variables* | | | | | |
| Specialization | 0.5583 | 1.0452 | 1.5098 | 22.0041 | 2.0633 |
| Competition (11 Industries) | 0.4449 | 1.0407 | 1.1129 | 5.0652 | 0.3010 |
| Diversification | -0.5714 | -0.4668 | -0.4606 | -0.3024 | 0.0451 |
| *Control variables* | | | | | |
| Education (log) | 4.8828 | 7.8326 | 8.0287 | 12.634 | 1.4694 |
| Residents (log) | 8.7091 | 11.2824 | 11.5011 | 14.5421 | 1.0622 |
| Average Income per Resident (log) | 11.8530 | 12.0939 | 12.0938 | 12.4267 | 0.0937 |
| National Industry Employment (log) | 9.1241 | 12.094 | 12.0777 | 12.7783 | 0.6490 |

**Note**: It should be noted that the competition variable is only represented in the 11-industry data set – and not in the 37-industry data set. See Appendix 4-6 for the variable characteristics for the data sets of 11 industries, 37 industries (high-tech), and 37 industries (low-tech).

All variables depicted in Table 8 are addressed in the following section to motivate their usage and their operationalization. Moreover, the potential influential outliers identified in Table 9 are examined in the analysis to ensure robustness of the regression results.

### 4.4.1. Dependent Variable

To investigate the relationship between industry structures and regional growth in the Danish commuting zones, this study uses employment as the dependent variable serving as a proxy for economic growth. In line with previous studies, employment is defined as the log of CZ-industry employment.

The main drawback of using employment growth in the context of externalities is primarily its shortcoming to interpret productivity. Here, total factor productivity is better capable of assessing the externalities, as these externalities "imply a change in output not fully accounted for by a change in inputs" (Bishop & Gripaios, 2010, p. 446). Accordingly, an increase in productivity may, at times, lead to diminished employment growth, as heightened productivity may imply layoffs. However, the majority of studies use employment instead, given a vast lack of data on sector level output and capital stock, such as Glaeser and colleagues (1992) as well as Bishop and Gripaios (2010). While regressions on employment growth may not provide direct implications for productivity, they do exhibit implications for employment. As a result, it is of specific relevance for policymakers concerning spatial externalities, in which politicians desire stable growth levels and lessening the divergence of growth across regions (Bishop and Gripaios, 2010). Taking note of the limitation of employment, the dependent variable remains valid and relevant for the purpose and scope of this study. Consequently, using CZ-industry employment as a proxy for regional growth, it is interesting to test whether MAR, Porter, Jacobs, or SGM explain regional growth in Denmark.

### 4.4.2. Key Independent Variables

In line with previous research, this paper investigates what the relationship is between the industry structure and regional growth in Denmark. As suggested by theory, specialization, competition, and diversity might have such a significant correlation with employment growth. Therefore, these variables have been chosen as this study's key independent variables.

MAR externalities and Porter suggest that specialization should have a positive impact on employment growth, since regional specialization allows for knowledge to spill over to other companies within the same industry. In this paper, the specialization variable is defined as the ratio of the commuting zone's employment that an industry constitutes relative to the proportion of the entire industry in national employment (Glaeser et al., 1992):

$$specialization = \frac{CZ\text{–}\, industry\ employment\ /\ commuting\ zone\ total\ employment}{industry\ employment\ in\ Denmark\ /\ total\ employment\ in\ Denmark} \qquad (2)$$

In this way, the specialization variable captures how specialized a given commuting zone is in an industry compared to the national average. Using this ratio approach, the variable corrects for the situation where industries are large, simply because they are located in highly populated areas such as Copenhagen or Aarhus.

In a similar vein, Porter (1990; 1998) and Jacobs (1969) argue that competition would be beneficial for regional employment growth rather than monopolistic competition. The reason is, according to Porter and Jacobs, that a highly competitive industry would force companies to innovate to survive, which would benefit society and regional employment. In this paper, competition is defined as the number of companies per worker in a specific CZ-industry relative to the number of companies per worker in the industry nationally (Glaeser et al., 1992):

$$competition = \frac{companies\ in\ CZ\!-industry\ \ /\ workers\ in\ CZ\!-industry}{companies\ in\ industry\ in\ Denmark\ /\ workers\ in\ industry\ in\ Denmark} \qquad (3)$$

If competition has a value greater than one, it means that there are more firms in this CZ-industry relative to its size, than there are in Denmark as a whole. Hence, a value greater than one indicates a higher degree of competition in this region, since more firms are competing. However, it is important to bear in mind that this variable not only indicates the degree of competition, but also captures the size of these companies. Thus, it may be that the companies in this region are just smaller than the national average but not necessarily more competitive. This is a very difficult distinction to make, as emphasized by previous researchers. Similar to Glaeser and colleagues (1992), the data of this paper does not include output data for all individual firms per CZ-industry, as this type of data is unavailable. This lack of data limits the possibility for constructing concentration ratios, which otherwise would give important insight into competition as well. Therefore, the competition variable in equation 3 is the optimal proxy of competition, given the available data.

The final key independent variable is diversification, which is expected by Jacobs (1969) to have a positive impact on employment growth. Jacobs argues that diversification allows for knowledge to spill over across industries, hence, allowing the industry in question to grow more rapidly (Glaeser et al., 1992). In this study, diversification is measured as the share of total employment the other five large industries account for in that specific commuting zone, illustrated as:

$$diversification = -\frac{(sum\ of\ top\ six\ CZ\!-industry\ employment -\ CZ\!-industry\ employment)}{total\ employment\ in\ the\ commuting\ zone} \qquad (4)$$

As such, this variable indicates whether the region is greatly diversified, heavily dependent on a few industries, or something in between. Contrary to most literature, a negative sign has been added to the formula, since it eases the interpretation. As the value of this variable increases, the commuting zone's industry structure becomes more diversified and, according to Jacobs, the foundation for employment growth in that regions improves.

In addition to these independent variables, however, it is important to be aware of differences between the regions and other factors that might influence the results. Therefore, a range of important control variables needs to be included to enhance the reliability of the results. Those control variables are presented in the next section.

### 4.4.3. Control Variables

Several control variables are included in the regression models to allow for testing of the relationship between the dependent and independent variables, as these regressors control for omitted factors that might otherwise influence the dependent variable (Stock & Watson, 2015). It is acknowledged that there is a risk of multicollinearity among these variables. However, this potential issue is accounted for in the analysis.

#### Education

The econometric models of this paper control for education, which acts as a proximate indicator of human capital within each commuting zone. In accordance with several studies controlling for the regional levels of human capital (cf. Frenken et al., 2007; Boschma et al., 2011; Eriksson et al., 2017), this control variable is defined as the number of people in that commuting zone holding at least a bachelor's degree.

Both Glaeser (2000; 2011) and Moretti (2013) argue that human capital in the form of higher levels of education is important for externalities, knowledge spillovers, and, ultimately, employment growth. Specifically, Moretti argues that the presence of many college-educated residents "results in high wages not just for the skilled workers but also for the workers with limited skills" (Moretti, 2013, p. 90). Moreover, Moretti (2013) also predicts that the future of global competition is to revolve around attracting human capital, where ideas and knowledge are often derived. Similarly, Glaeser (2011, p. 223) claims that "to thrive, cities must attract smart people and enable them to work collaboratively. There is no such thing as a successful city without human capital." Hence, education is added to control for different levels of education across Danish commuting zones.

#### Number of Residents

As with education, it is important to control for the number of residents when analyzing the drivers of employment. Therefore, the number of residents in each commuting zone is added as a control variable in all the regression models, in line with previous studies (cf. Frenken et al., 2007; Bishop & Gripaios, 2010; Eriksson et al., 2017). In this way, the models control for the fact that the population is growing in some commuting zones, while contracting in others, mainly due to the urbanization trend. Consequently, an employment increase in a CZ-industry will not simply be explained by an increase in residents in these models, as the models control for residents.

#### Average Income per Resident

Another important aspect to consider is the average income per resident, since higher salaries will attract more workers, all else equal. Jespersen (2003) incorporates income as the dependent variable in his analysis of regional productivity growth, which emphasizes income's importance for regional growth. Therefore, average income per working-age resident has been included as a control variable in the regression models.

### National Industry Demand

Lastly, as emphasized by Glaeser and colleagues (1992), it is essential to control for changes in national industry demand when analyzing the effects of dynamic externalities. In this paper, the national industry demand variable is defined as the number of employees in the industry at a national level. By including this variable as a control, the models will correct for a situation where the industry is growing simply because the industry is growing nationally. Thus, this study will investigate, for example, whether consulting has grown faster than the average in particular regions, controlling for how the consulting industry has grown in the nation as a whole.

## 4.5. Econometric Model

In the following section, the econometric method is outlined. Accordingly, several considerations for appropriate panel data analysis are specified, followed by econometric tests to ensure reliable and valid regression estimations. Based on balanced panel data with observations across all entities for all 12 time periods, a fixed effects regression model is applied in this paper. The specifications of this regression model are addressed in the following sections.

### 4.5.1. Panel Data Analysis

Panel data – also referred to as longitudinal data – is particularly attractive for studying employment growth across regions over time, as it combines cross-sectional and time-series data, allowing for richer estimations (Croissant & Millo, 2019). It provides data for multiple entities in which each entity is observed at least at two time periods. Accordingly, the general linear panel model looks as follows:

$$y_{it} = \alpha_{it} + \beta^{\mathrm{T}} X_{it} + u_{it} \tag{5}$$

Here, $i = 1, \ldots, n$ denotes the observed entity (in this case, a commuting zone), and $t = 1, \ldots, T$ denotes time at which the entity is observed. Moreover, $\alpha_{it}$ represents the unknown entity-specific intercepts that are to be estimated. Additionally, multiple independent variables, $X_{it}$, are included, given that economic theory predicts these are correlated with the dependent variable. In this case, specialization, competition, and diversification are the multiple regressors along with some control variables. Lastly, $u_{it}$ denotes the error term (Ibid.).

Under homoskedasticity, the variance of the error term is assumed to be constant across all observations whereby $\alpha_{it}$ equals $\alpha$, and $\beta_{it}$ equals $\beta$ across time and entities (Baltagi, 1995). If these assumptions hold, the data can be pooled into one model, where all the cross-sections of the data are pooled together, ignoring potential entity or time effects (Croissant & Millo, 2019).

If the error term is heteroskedastic, however, this assumption may be violated. While the regression coefficient will remain consistent, these estimates are no longer efficient (Baltagi, 1995). Through the fixed effects model, one can account for unobserved heterogeneity – that is, allowing commuting zones to be different – by letting the error term be:

$$u_{it} = \mu_i + v_{it} \tag{6}$$

The $v_{it}$ is the remaining disturbance that varies with entities and time while assumed stochastic, independent, and identically distributed. Meanwhile, the $u_i$ is the unobserved, time-invariant fixed effect of the dependent variable. In other words, this component is the unobservable effect of an entity, $i$, on the dependent variable, $y$ (Ibid.). Where a fixed effects model holds that the $u_i$ is correlated with the independent variables, a random effects model is applicable when this entity-specific component is uncorrelated with the regressors (Croissant & Millo, 2019).

A number of advantages are associated with panel data analysis. First and foremost, one can avoid severe issues of omitted variable bias, as one only investigates the changes in the dependent variable within a selected time interval (Stock & Watson, 2015). Here, one can control for variables that may differ across entities but not over time. Moreover, panel regression also allows one to control for the assumption that external shocks to the national economy may change over time but not across entities. Additionally, panel regressions have three other advantages, as they: 1) allow for control of heterogeneity, 2) are better able to discern and estimate effects, and 3) give more variability and efficiency compared to time-series and cross-sectional data that risk bias or serious misspecification, since these regressions cannot control for entity- and time fixed effects (Baltagi, 1995). Similar to cross-sectional and time-series data, though, is that panel data can suffer from design and data collection problems, measurement error, self-selectivity, and short timespan in the data. Nevertheless, panel data analysis is deemed the most relevant approach for the data set of this paper.

### Fixed Effects Model

A fixed effects regression is an addition to multiple regression, in which one can utilize panel data to control for variables that may differ across entities but not over time – that is, the entity effects, $\mu_i$ in equation 6 (Stock & Watson, 2015). In line with Glaeser and colleagues (1992, p. 1134), this study "assumes that knowledge spillovers are constant over time," since the industry structure within a commuting zone is related to the past historical structure (Neffke et al., 2011). Besides controlling for the entity effects, a fixed effects model can be extended to account for time effects as well, as seen in the following fixed effects regression:

$$y_{it} = \alpha_{it} + \beta^{T} X_{it} + \mu_i + \lambda_t + v_{it} \tag{7}$$

The new additions in equation 7 – compared to equation 5 – are the additional intercepts for the entity fixed effects, $\mu_i$, and the time fixed effects, $\lambda_t$, making it a two-way error component regression model. Similar to the entity fixed effects, the variation in the time fixed effects stems from omitted variables. The time fixed effects change over time but are constant across entities. Again, the $X_{it}$ is assumed independent of the $v_{it}$ across all entities and time periods (Baltagi, 1995).

To compute the OLS fixed effects, the data is transformed using the 'within' estimator in the "plm"-package in the statistical software program $R$. This is coined entity-demeaning, where the software practically subtracts the average of entity-specific variables from each variable and estimates the multiple regression using these variables, which is shown by the following equation:

$$y_{it} - \bar{y}_i = \beta_1(X_{it} - \bar{X}_i) + (\mu_{it} - \bar{\mu}_i) \tag{8}$$

Here, $\bar{y}_i$ and $\bar{x}_i$ denote the entity means of $y$ and $x$. Accordingly, the 'within' estimator involves regression on this transformed data such that the entity effects disappear – or are "transformed out" (Croissant & Millo, 2019, p. 33). Similarly, the time-specific variables can be demeaned, essentially using the same process as entity-demeaning.

Generally, the fixed effects model is "one of the simplest and most robust specifications in panel data econometrics," where the macro-panel data in this study fits well with this model in terms of the sample being fixed (Ibid., p. 5).

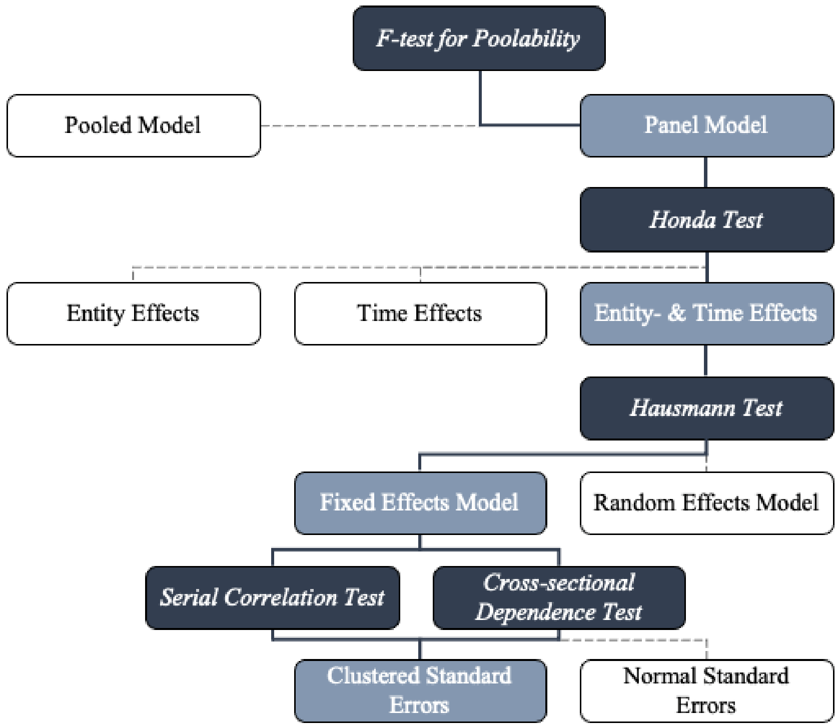
### Random Effects Model

Compared to the fixed effects model, the random effects model is more efficient, when the entity-specific component, $\mu_i$, is uncorrelated with the regressors, $X_{it}$ (Ibid.). This implies that the error term, $u_{it}$, is similarly uncorrelated with the independent variables, whereby the OLS regression is possible through generalized least squares (GLS). While holding that the entity effects stem from random observations from a particular distribution, the GLS estimator aims to measure the variables of this distribution to obtain efficient coefficients (Ibid.). Contrary to the fixed effects model, the random effects model allows the coefficients to randomly move around a common average, whereas fixed effects only assume the coefficient to vary around one dimension (Croissant & Millo, 2008). While the random effects model is usually considered more efficient with smaller standard errors, many economists tend to use a fixed effects model, as it is more robust (Croissant & Millo, 2019). With this in mind, the Hausman test will compare the fixed and random effects models and specify which one is most appropriate to assess the longitudinal data.

### 4.5.2. Econometric Test

There is a range of tests applicable for rightly specifying the regression equation, as seen in Figure 2 below:

**Figure 2**: Workflow of Econometric Tests Applied to the Data




**Source**: Author's creation

Specifically, it is necessary to test whether the data should be pooled, should account for entity effects, time effects, or both, and whether it is to be corrected for serial correlation and cross-sectional dependence. Additionally, a Hausman test determines whether a fixed effects or random effects model is the best fit for studying this data set.

### Test for Poolability of the Data

Initially, the test of poolability is applied to identify whether entities are sufficiently homogenous to pool the entities and run a standard OLS model or whether a panel model ensues, given entity heterogeneity. Under the restricted (pooled) model, a regression model with the "same parameters over time and across regions [cf. entities]" can be run, since the parameters do not differ from one region to the others across all regions in the data (Baltagi, 1995, p. 47). Conversely, if the applicability of the pooled model is rejected, different parameters over time and entities are suitable for the model (Ibid.).

To test whether the pooled OLS is stable or unstable, one can use a Chow test via the 'pooltest' function in *R*, which results in an F statistic indicating whether to use a pooled model or a panel model (Croissant & Millo, 2019). With the panel data on Danish commuting zones, the F statistic indicates that the coefficients of the panel model are unstable, whereby the feasibility of a pooled model is rejected for this study.

### Test for Entity- and Time Fixed Effects

A Breusch-Pagan Lagrange-multiplier (LM) test examines whether entity fixed effects, time fixed effects, or both are evident in the model. Under the null hypothesis of no entity nor time fixed effects, the pooled OLS model is applicable, whereas a panel model is suitable if $H_0$ is rejected (Baltagi, 1995). Using OLS residuals, the following null hypothesis is tested when considering a two-way error component model:

$$H_0:\ \sigma_\mu^2 = \sigma_\lambda^2 = 0 \tag{9}$$

The null hypothesis states that the variance of the residuals is zero, whereby the entity- and time fixed effects are absent. There is a shortcoming of the Breusch-Pagan LM test, as it allows for the alternative hypothesis to be two-sided, when it in fact can only be nonnegative. Accordingly, Croissant and Millo (2019) recommend using a Honda test, in which the effects' variance is only allowed to be one-sided and nonnegative.

Applying the 'plmtest' function in *R* and specifying the Honda test-type, the p-value is below the 0.05 significance level indicating that both effects are present. Accordingly, the panel regression model is to include entity- and time fixed effects when analyzing the relationship between industry structures and employment in Danish regions.

### Hausman Test

Essentially, the Hausman test examines whether there is a possible correlation between the covariates and the entity effects in a one-way error component model. The procedure is similar for a two-way error model with both entity- and time effects (Ibid.). This test for using fixed or random effects models is justified, as one cannot rule out whether the entity heterogeneity is correlated with the regressors or not. Accordingly, the Hausman test explores the following hypothesis:

$$H_0:\ E\left(\frac{u_{it}}{X_{it}}\right) = 0 \tag{10}$$

Here, the random effects model is only consistent and efficient, when the null hypothesis holds, "but is inconsistent when $H_0$ is false" (Baltagi, 1995, p. 68). Accordingly, when the entity effects are uncorrelated – $H_0$ holds – the random effects and fixed effects are consistent, but the random effects model is comparatively more efficient.

Contrarily, when the $H_0$ is false, the entity effects are correlated with the error term, and only fixed effects estimates are consistent (Croissant & Millo, 2019).

Based on the Hausman test using the 'phtest' function in *R*, this study employs fixed effects regression models, as the null hypothesis of zero correlation between the entity- and time effects with the regressors is rejected.

### Test for Serial Correlation and Cross-Sectional Dependence

Using the 'pbgtest' function in *R*, one can use the Breusch-Godfrey test to detect serial correlation in the data, as "a model with individual [cf. entity] effects has composite errors that are serially correlated by definition" (Ibid., p. 95). Specifically, this form of auto-regressive test applies to a fixed effects model when *T* is long enough. Accordingly, the Breusch-Godfrey test examines whether the remaining disturbance term, $v_{it}$, is serially correlated within an entity over time. If the test indicates that the error is serially correlated, but this is ignored by the researcher, then the estimated coefficients and standard errors are consistent but inefficient (Baltagi, 1995). One way to account for serial correlation and heteroskedasticity is to use clustered standard errors (Stock & Watson, 2015). With clustered standard errors, each cluster constitutes an entity, whereby the "standard errors allow the regression errors to have an arbitrary correlation within a cluster, or grouping, but assume that the regression errors are uncorrelated across clusters" (Ibid. p. 413).

Similarly, the clustered standard errors can be used to account for cross-sectional dependence. This issue pertains too, if an entity is dependent on another entity within the panel data (Sarafidis & Wansbeek, 2012). To test for cross-sectional dependence, the most common test is the Breusch-Pagan LM test, as described above, where the test statistic is based on the entity-specific residuals from an OLS regression (Ibid.).

The null hypotheses of both the Breusch-Godfrey and the Breusch-Pagan LM test are rejected, as they both display p-values lower than the 0.05 significance level. Hence, clustered standard errors are applied to the panel regression models in this study to correct for serial correlation and cross-sectional dependence over time.

### 4.5.3. Final Regression Model

Following the various tests above, the main regression model below is applied in the analysis of the data:

$$\begin{aligned} Employment\ growth_{it} &= \beta_1 Specialization_{it} + \beta_2 Competition_{it} + \beta_3 Diversification_{it} + \beta_k Controls_{it} \\ &+ \mu_i^{Commuting\ Zones} + \lambda_t^{Year} + v_{it} \end{aligned} \tag{1}$$

Here, $i = 1, \ldots, n$ denotes the observed commuting zone, and $t = 1, \ldots, T$ denotes time at which the commuting zone is observed. Moreover, both entity- and time fixed effects are included – signified by the $\mu_i$ and $\lambda_t$ – followed by the remaining disturbances captured in $v_{it}$. Besides the key independent variables, the control variables of education, number of residents, average income, and national industry demand are included with a coefficient, $\beta_k$, attributed to each specific variable. Accordingly, this regression model is employed to analyze which industry structures are related to regional growth in the Danish commuting zones. Specifically, equation 1 is applied to the data set of 11 industries, as this data set includes data on the number of firms per CZ-industry. Meanwhile, a similar regression equation is applied to the data sets of 37 industries and the high- and low-tech data sets but without the competition variable, due to data unavailability for these data sets.

## 4.6. Generalization

The ability of this paper to generalize findings and extrapolate those to other countries or time periods is moderately limited. However, the quantitative method applied allows for deeper insights specifically into the Danish regions during the post-financial crisis period, while highlighting possibilities for future research. Furthermore, since this paper builds upon the general method proposed by Glaeser and colleagues (1992), this paper seeks to complement the combined literature base on dynamic externalities and knowledge spillovers throughout the past decades. The combined findings of this pool of research present insights for policymakers in conducting employment-related policies on a regional level.

## 4.7. Sub-Conclusion

This section of the paper has outlined the methodical approach applied to answer the overall research question of "*What is the relationship between the industry structure and regional growth in Denmark in the years following the financial crisis?"* Through the application of a quantitative research method and with a deductive research approach, empirical data analysis is conducted on data for 29 Danish commuting zones between 2008 and 2019. In line with Glaeser and colleagues (1992), this paper uses employment growth as the dependent variable. Specialization, diversification, and competition are the independent variables that serve to explain what drives employment growth in Danish regions, while controlling for a number of factors. Because of the longitudinal nature of the data, a fixed effects model is deemed most relevant, as it allows for richer estimations through the combination of cross-sectional and time-series data. This method is applied in the following section, where the data is analyzed and the results are presented.

# 5. Analysis and Findings

Based on the data collection and choice of variables along with the econometric model specifications above, the following equation is run to analyze the relationship between the industry structures and employment growth in the 29 Danish commuting zones from 2008 to 2019:

$$
\begin{aligned}
&Employment\ growth_{it} \\
&\quad = \beta_1 Specialization_{it} + \beta_2 Competition_{it} + \beta_3 Diversification_{it} + \beta_k Controls_{it} \\
&\quad + \mu_i^{Commuting\ Zones} + \lambda_t^{Year} + v_{it}
\end{aligned}
\tag{1}
$$

Applying this regression formula to the industrial aggregations of 37 and 11 industries as well as for high- and low-tech industries, separately, allows this paper to test the effect of industry structure on regional growth. The competition variable, however, is only included in the 11-industry data set.

In the subsequent sections, there is an initial review of the key independent variables' correlations, results of the econometric tests allowing for the correct model specification, and the results from the four main regression models. In line with MAR externalities, these results suggest that the specialization of industries is positively associated with employment growth, while competition is negatively related to employment growth. There is partial evidence of Jacobs externalities through a positive relationship of diversification with employment growth. Accordingly, hypotheses H3, H4, and H5 cannot be rejected, whereas hypotheses H1 and H2 are both rejected. These findings are scrutinized in terms of validity and robustness at the end of the analysis.

## 5.1. Correlation Matrix

Before performing the regression analysis, it is appropriate to assess the correlation among the incorporated key independent variables that follow from economic theory. This correlation matrix allows an evaluation of potential multicollinearity issues besides an initial indication of the relationship between the variables at hand.

**Table 10**: Pearson's Correlation Matrix for Model I-IV

Model I: 37 Industries

| | Specialization | Diversification |
|---|---|---|
| Specialization | 1.0000 | |
| Diversification | -0.1785* | 1.0000 |

Model II: 11 Industries

| | Specialization | Competition | Diversification |
|---|---|---|---|
| Specialization | 1.0000 | | |
| Competition | -0.3323 | 1.0000 | |
| Diversification | -0.1551* | 0.1546* | 1.0000 |

Model III: 37 Industries (High-Tech)

| | Specialization | Diversification |
|---|---|---|
| Specialization | 1.0000 | |
| Diversification | -0.1494* | 1.0000 |

Model IV: 37 Industries (Low-Tech)

| | Specialization | Diversification |
|---|---|---|
| Specialization | 1.0000 | |
| Diversification | -0.2515* | 1.0000 |

**Note**: See Appendix 7 for the full correlation matrices including the control variables. The asterisk indicates the 0.05 percent significance level.

From Table 10, it is evident that diversification and specialization are significant and negatively correlated in all four data sets. Hence, even though they are not perfectly negatively correlated, there seems to be some opposing effects between specialization and diversification. In addition, competition and diversification are significant and positively correlated in Model II. Overall, it does not appear that any multicollinearity problems arise among the key independent variables. Together with this initial review of the variables, econometric tests are carried out to specify the most valid and robust regression models.

## 5.2. Econometric Tests

Several econometric tests are conducted to arrive at the final regression models, which are the most suitable to the longitudinal data at hand and to accommodate any potential biases. The results of these tests are summarized in Table 11:

**Table 11**: Econometric Tests

| Data Set | Poolability | Entity- and Time Fixed Effects | Fixed- or Random Effects | Serial Correlation | Cross-Sectional Dependence |
|---|---|---|---|---|---|
| 37 Industries | Not Applicable | Both Effects | Fixed Effects Model | Detected | Detected |
| 11 Industries | Not Applicable | Both Effects | Fixed Effects Model | Detected | Detected |
| High-Tech Industries (37 IND) | Not Applicable | Both Effects | Fixed Effects Model | Detected | Detected |
| Low-Tech Industries (37 IND) | Not Applicable | Both Effects | Fixed Effects Model | Detected | Detected |

**Note**: For detailed test-statistics from each test, please see Appendix 8-12.

The results from Table 11 suggest that fixed effects models – accounting for entity- and time fixed effects and including clustered standard errors – are the most suitable models for the data. The tests and their results are discussed in more detail in the following section.

### Test for Poolability

A Chow test for poolability is applied to check whether the same standardized coefficients apply to all commuting zones. This null hypothesis is tested via an F-test that indicates whether the pooled OLS is stable or unstable. From Appendix 8, it is evident that the same slope of the regressors does not apply across all commuting zones. At the 0.05 significance level, the null hypothesis is rejected with an F-statistic of 93.39 for the data set containing 37 industries. Thus, the longitudinal data is not poolable, and it is more appropriate to use panel models. Similar results are reached with the data sets for 11 industries, high-tech industries, and low-tech industries. To correctly specify these panel models, it is necessary to first determine whether entity-, time-, or both fixed effects are present in the panel data.

## Honda Test for Entity- and Time Fixed Effects

Via Honda's test, it is possible to examine whether variances of the commuting zone fixed effects, time fixed effects, or both effects are zero. Accordingly, the null hypothesis of $H_0$: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ is tested with a Lagrange multiplier statistic (Baltagi, 1995). With a test statistic of 75.36 for the 37-industry data set, $H_0$ is rejected at a 0.05 significance level (Appendix 9). Similar conclusions have been attained for 11 industries as well as high- and low-tech industries. In other words, the test for all data sets strongly rejects that there are no entity nor time fixed effects present. Both effects should, accordingly, be included in the regression models via the two-way error component.

## Hausman Test

The Hausman test allows one to examine whether the data is subject to a random or fixed effects model by investigating the correlation among the covariates and the entity- and time fixed effects. Specifically, the test compares the fixed effects model with the random effects model and its estimates for the regression equations for the respective data sets. The Hausman test shows that the null hypothesis of zero correlation between the entity- and time fixed effects with the error term is rejected for all data sets (Appendix 10). Thus, the estimates of the random effects model are not consistent and not considered best linear unbiased estimate (BLUE), whereas the fixed effects estimates are. As a result, the regressions below will follow a fixed effects model.

## Test for Serial Correlation

Based on the results of the Hausman test, it is viable to consider if the data is subject to serial correlation in the idiosyncratic errors. The Breusch-Godfrey/Wooldridge test allows one to inspect this potential issue within longitudinal data sets. Appendix 11 displays the results of the tests, in which the data sets have a large chi-squared statistic of 888.27 and 581.71 for the 37- and 11-industry data sets, respectively. Similar results have been obtained for the high- and low-tech data sets. Consequently, the null hypotheses are rejected, indicating the need to include clustered standard errors to correct the evident serial correlation in the data.

## Test for Cross-Sectional Dependence

Via a Breusch-Pagan LM test, it is possible to examine whether the errors are biased due to cross-sectional dependence within entities. With a chi-squared statistic of 44,992 for the 37-industry data set and similar large test-statistics for all other data sets, the null hypotheses of no cross-sectional dependence are rejected at a 0.05 significance level for all models (Appendix 12). To correct this bias, clustered standard errors are again necessary to include in the final models.

## 5.3. Final Model

Following the econometric tests, the final regression models are applied to the 37-industry, 11-industry, and the high- and low-tech industry data sets. The results of all these models are presented in Table 12.

**Table 12**: Regression Models on Employment in Danish Commuting Zones (2008 to 2019)

| **Dependent variable** | **CZ-Industry Employment** | | | |
|---|---|---|---|---|
| | (I)<br>37 IND | (II)<br>11 IND | (III)<br>High-Tech<br>37 IND | (IV)<br>Low-Tech<br>37 IND |
| Specialization | 0.1510***<br>(0.0548) | 0.5101***<br>(0.0726) | 0.4916***<br>(0.1136) | 0.5559***<br>(0.0865) |
| Competition | | -0.2306***<br>(0.0659) | | |
| Diversification | 0.4365*<br>(0.2488) | -0.0167<br>(0.0912) | -2.8628<br>(2.5097) | 1.0620<br>(1.3083) |
| Control Variables | INCLUDED | INCLUDED | INCLUDED | INCLUDED |
| Entity Fixed Effects | YES | YES | YES | YES |
| Time Fixed Effects | YES | YES | YES | YES |
| Observations (*N*) | 2,088 | 2,088 | 1,872 | 1,872 |
| Adjusted $R^2$ | 0.4635 | 0.8778 | 0.4879 | 0.5057 |
| F-statistic | 332.1700***<br>(df = 6; 1,897) | 2,169.5000***<br>(df = 7; 1,896) | 325.7050***<br>(df = 6; 1,699) | 347.7260***<br>(df = 6; 1,699) |

**Note**: The table depicts the four fixed effects regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors, which are reported in the parentheses. Ærø, Tønder, and Aabenraa are omitted from the data in Model III and IV due to no employment in several high- and low-tech industries. For further information on the results for the control variables, please see Appendix 13. Significance levels are indicated by the asterisks with *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Specialization of industries appears to be significant and positively associated with employment. Competition is significant and negatively related to regional employment, while diversification is positive and weakly significant in Model I. These results are discussed in further detail below.

### 5.3.1. MAR Externalities at Play in Denmark

In the following section, the results of the three key independent variables are discussed for Model I and II, while also building the foundation for an assessment of hypothesis H1 to H3.

### Specialization

Based on the empirical literature base, the first hypothesis of this paper states:

*Hypothesis 1 (H1): More specialization of CZ-industries is negatively associated with regional employment growth.*

According to the results in Table 12, H1 is rejected, since specialization is strongly significant and positively associated with employment at a 0.01 significance level for the Model I. This result suggests that more specialized regional industries will experience higher growth in employment. The coefficient is 0.15, meaning that a one-unit increase in specialization is associated with a 15% increase in industry employment, all else equal. However, since specialization and the other independent variables are ratios, a one-unit increase seem implausible for most regional industries. Therefore, a 0.1-unit increase in specialization – which is related to a 1.5% increase in employment – is deemed more realistic. This interpretation is applied in the remainder of the analysis.

For the 11-industry data set, specialization is also significant and positively related to employment at a 0.01 significance level. In this case, the coefficient is relatively larger at 0.51. Hence, for Model II, a 0.1-unit increase in specialization is associated with a 5.1% increase in industry employment. Accordingly, it seems that with a higher aggregation of industries, specialization plays an increasingly important role for employment growth. This is in line with the considerations of Beaudry and Schiffauerova (2009), who argue that higher aggregations of industries will favor specialization effects. Both results for Models I and II are consistent with MAR externalities and Porter’s industry cluster theory, as both theories claim that specialized industries will experience more intra-industry knowledge spillovers and, thus, higher employment growth. The findings of MAR externalities align with the results of van der Panne (2004) and Song and colleagues (2019) in terms of knowledge spillovers within sectors being positively related to regional growth.

An example of a specialized regional industry is the financial sector in Aabenraa, which experienced an increase in employment of 6.4% over the sample period, from 1,323 employees in 2008 to 1,408 in 2019. This industry performed better than the Aabenraa commuting zone, which experienced an overall decrease in employment of more than 9%. The main reason for this high concentration of finance companies – compared to what Aabenraa's size otherwise suggests – is the fact that the headquarters of the third-largest bank in Denmark, Sydbank, is located in the region (Finanstilsynet, 2020). Hence, with Sydbank as its flagship, the specialized finance industry of Aabenraa outperformed the general downward employment trend in the region.

Another example of a specialized CZ-industry is the food, beverage, and tobacco industry in Frederikshavn. Here, employment increased from 1,781 employees in 2008 to 1,946 in 2019 – an increase of 9.3% – compared to an overall decrease in employment of 12% in Frederikshavn. Part of the reason for the specialization of Frederikshavn in the food industry is that Danish Crown – one of the world's largest exporters of pork meat (Danish Crown, n.d.) – has located one of its larger factories in Sæby. As with the finance sector in Aabenraa, the specialization of food companies has arguably assisted this regional industry to thrive in Frederikshavn.

## Competition

Based on the theories of Jacobs, Porter, and the general empirical evidence, the second hypothesis of this paper states that:

*Hypothesis 2 (H2):* *Fiercer competition within CZ-industries is positively associated with regional employment growth.*

However, with the results from Table 12, hypothesis H2 is rejected, since the competition variable is both strongly significant and negatively related to employment at a 0.01 significance level. The coefficient is -0.23, meaning that a 0.1-unit increase in the competition variable is associated with a decrease of 2.3% in industry employment, keeping everything else constant. In other words, less competition will improve regional industry employment. This result is in line with MAR externalities that promote the idea of monopoly competition, since externalities can then be internalized by the innovator. Moreover, this finding is in accordance with van der Panne (2004), who concludes that less fierce competition positively affects regional growth.

An example of a CZ-industry characterized by little competition is the trade and transportation sector in Herning. This industry went from 14,443 employees in 2008 to 14,759 in 2019 – an increase of 2.2% – while the commuting zone of Herning faced a decrease of 1.7% in total employment. The main reason for the limited competition in this regional industry is that Bestseller – one of the largest fashion groups in the Nordics – has located its headquarters in Brande (Bestseller, n.d.). With Bestseller's dominating position in Herning, the less fierce competition has arguably helped in creating jobs in the industry, according to the results.

Similar to the trade and transportation industry in Herning, the business service industry in Ringkøbing-Skjern is also characterized by a lesser degree of competition. This industry went from 1,884 employees in 2008 to 2,093 in 2019 – an increase of 11% – while the region experienced a decrease in employment of more than 10%. One reason for this relatively low level of competition in the business service industry in Ringkøbing-Skjern is that JSK – one of Denmark's leading temporary worker- and recruiting companies – is located in Ringkøbing (JKS, n.d.). Hence, as suggested by MAR externalities, companies in the business service industry in this region might have been better able to internalize externalities from innovations and therefore outperform other industries.

### Diversification

Based on the expected presence of Jacobs externalities in the Danish commuting zones, the third hypothesis of this paper is formulated as follows:

*Hypothesis 3 (H3):* *More diversification of CZ-industries is positively associated with regional employment growth.*

From Table 12, hypothesis H3 cannot be rejected. The diversification variable in Model I is weakly significant and positively associated with employment at a 0.1 significance level. The coefficient is 0.44 indicating that a 0.1-unit increase in the diversification variable is associated with an increase in employment of 4.4%. This finding of Jacobs externalities is consistent with several academic papers (Glaeser et al., 1992; Feldman & Audretsch, 1999; Frenken et al., 2007). In addition, Glaeser (2011, p. 72) argues that "unemployment rates were almost three percent higher in the downturns of the 1970s and 80s in places that lacked a diverse range of employers", consistent with the results of Model I. In Model II, however, the variable becomes negative and insignificant. Thus, by aggregating industries at a higher level, diversification becomes insignificant, in line with Beaudry and Schiffauerova's (2009) argument that a higher aggregation of industries will result in a greater likelihood of finding MAR- rather than Jacobs externalities.

Horsens is an example of such a region with a more diversified industry structure relative to other Danish regions. Horsens experienced an increase in overall employment from 59,876 employees in 2008 to 61,924 in 2019 – an increase of 3.4%. Additionally, Horsens is one of only five regions that experienced employment growth during the sample period, together with much larger regions such as Copenhagen and Aarhus (Graph 5). Thus, Horsens' degree of diversification might have helped them create jobs, since the employment growth in Horsens has likely been helped less by urbanization. On the contrary, urbanization has likely benefitted the larger university regions relatively more – for example, Copenhagen and Aarhus. Additionally, the industrial diversification of Horsens might also explain the reduced effect of the financial crisis on employment, since Horsens' employment performed much better than many other regions after the crisis. From 2008 to 2012, Horsens' employment level decreased by only 5.7%, while it decreased by 11.6% in Sønderborg, for example.

In contrast to Horsens, Sønderborg has a relatively undiversified industry structure, as the largest industries in Sønderborg account for a large proportion of overall employment. Sønderborg's employment in 2008 was 32,867 employees, while it was only 29,789 in 2019, a decrease of 9.4%. One reason that Sønderborg is relatively undiversified might be the presence of Danfoss – a large industrial firm producing machines for climate and power solutions (Bang, 2021). Danfoss' location might have made Sønderborg too dependent on the machine industry and, ultimately, made the region vulnerable to industry-specific shocks or strategic decisions made by firms. This scenario appears to be the case, since the machine industry – Sønderborg's largest industry in 2008 – experienced a loss of employees of more than 42% over the sample period, decreasing from 5,912 employees in 2008 to 3,423 in 2019. The example of Sønderborg underlines the risk of a too undiversified industry structure.

### 5.3.2. Specialization Effects in High-Tech and Low-Tech Industries

Taking a closer look into knowledge spillovers within the high- and low-tech industries allows for an examination of industries and services of both mature low-tech industries and new high-tech industries. The motivation for this focused investigation is grounded in the increasingly educated population and the service-dominant logic in developed countries (Goffin & Mitchell, 2017).

To this end, the following section revolves around the relationship of high- and low-tech industries and employment levels in Danish commuting zones. Here, the regression Models III and IV in Table 12 suggest that hypotheses H4 and H5 cannot be rejected. The models' findings are interesting given that high- and low-tech sectors do not markedly differ from other sectors as investigated in Model I and II (cf. Jespersen, 2003).

### High-Tech

Based on empirical evidence by Henderson and colleagues (1995), the fourth hypothesis of this paper states:

*Hypothesis 4 (H4):* *High-tech industries experience higher employment growth in regions with more diversification of CZ-industries.*

On account of the results from Table 12, hypothesis H4 cannot be rejected. From Model III regarding industries within the high-tech sector, the diversification variable is insignificant but negatively associated with employment. In other words, enhancement of employment growth in high-tech industries and services appear not to be explained by diversified industry structures within commuting zones.

On the other hand, the specialization variable is strongly significant and positively related to employment at the 0.01 significance level. The coefficient of 0.49 suggests that a 0.1-unit increase in specialization within a high-tech CZ-industry is associated with a 4.91% increase in CZ-industry employment, on average. Accordingly, this finding suggests that if a region is specialized within a high-tech manufacturing or service industry, then employment in this regional industry grows relatively more than in other regions.

An example of such a specialized high-tech industry is the transport manufacturing industry in Grenå, which has experienced an increase in employment by 74% over the same period. This is likely connected to the prospering company of Terma Aerostructures A/S – an advanced technology and service provider within naval, airborne, and space program solutions – which is the largest company in the commuting zone (Andersen, 2020). This example indicates the presence of MAR externalities and suggests that industrially specialized regions in the high-tech sector will experience greater increases in employment levels.

Empirically, most studies find no correlation between industrial specialization within high-tech manufacturing and employment growth but rather with diversification (cf. Henderson et al., 1995; Paci & Usai, 1999). Alternatively, van der Panne's (2004) finding on drivers of regional innovativeness in the Netherlands corresponds to Model III above, suggesting that an increase in industrial specialization within an R&D-intensive industry more than proportionally affects regional innovativeness.

### Low-Tech

Through an expected presence of MAR externalities in the Danish commuting zones concerning low-tech industries, the fifth hypothesis of this paper is as follows:

*Hypothesis 5 (H5):* *Low-tech industries experience higher employment growth in regions with more specialization of CZ-industries.*

The results from Model IV in Table 12 suggest that hypothesis H5 cannot be rejected. Here, the specialization variable in Model IV is strongly significant and positively associated with employment at a 0.01 significance level. The coefficient is 0.56, meaning that a 0.1-unit increase in specialization within a low-tech CZ-industry relates to a 5.56% rise in the level of CZ-industry employment, all else equal. This finding reflects that a region consisting largely of low-tech manufacturing industries and less knowledge-intensive services benefits from increased industrial specialization on the level of employment. Comparatively, the coefficient for the specialization variable of 0.56 in Model IV is higher than 0.49 in Model III. This indicates that specialization in low-tech industries is relatively more related to employment growth than within high-tech industries. Thus, if an industry is specialized within the low-tech sector, then employment in this regional industry grows more relative to other regions.

Specifically, LEGO A/S – the leading producer in the toy industry (Bødker, 2020) – in the commuting zone of Vejle and Fredericia exemplifies the conceptualization of MAR. The CZ-industry in which LEGO A/S operates has experienced employment growth of 40% from 2008 to 2019, while employment in the region has grown by 1.2%. Similarly, this is illustrated by Taasinge Elementer A/S – the leading producer of prefabricated roof and facade elements in wood (Taasinge Elementer, n.d.) – in Svendborg. The 'timber- and paper industry (and printing plants)' in Svendborg has experienced employment growth of 11.5% in the sample period, whereas employment has diminished by 10% in the whole region. These examples demonstrate that industrially specialized regions in the low-tech sector arguably experience increases in employment levels compared to less specialized regions.

The finding of specialization effects in low-tech industries corresponds with the findings by Henderson and colleagues (1995) concerning the prevalence of MAR externalities for mature capital goods industries. Similarly, Greunz' (2003) finding on low- and medium-high tech sectors display similar externalities, although he remarks that there is some evidence of Jacobs spillovers. This appears not to be the case in Model IV, since the diversification variable is positive and insignificant in line with Henderson and colleagues' (1995) as well as Paci and Usai's (1999) findings.

### 5.3.3. Explanatory Power and the Validity of the Models

To assess the explanatory power of the models, one is to examine the $R^2$-values. The adjusted $R^2$ is within the span of 0.46 to 0.51 for Models I, III, and IV. These $R^2$-values indicate a relatively strong predictive power of the models, as much of the variance in the dependent variable is explained by the independent variables. Nonetheless, to fully assess the explanatory power of the models, the $R^2$ values are compared to papers with a similar field of scope. Here, Glaeser and colleagues' (1992) $R^2$-values range from 0.39 to 0.45, while Frenken and colleagues' (2007) $R^2$-values vary from 0.45 to 0.65. Accordingly, with comparatively similar values for $R^2$, the models in regression Table 12 show explanatory power of equivalent strength to these papers. The $R^2$-value of Model II, however, is noticeably high at 0.88, although Henderson and colleagues (1995) reach similar $R^2$-values of 0.73 to 0.87 in their models. This high $R^2$-value might indicate some degree of imperfect multicollinearity for the 11-industry data set, which is addressed in the robustness check of the regression results.

The standard errors measure the distances of the observed value from its predicted value (Stock & Watson, 2015). Through the application of clustered standard errors, the deviation of the variables from the regression line remains small overall, thereby showing validity of the results. Notably, the diversification variable in Model I has relatively high standard errors, which is also evident in the parameter estimate being only weakly significant.

Overall, the regression models display appropriate explanatory power with generally small standard errors, whereby the data is assessed as qualitatively valid. Nonetheless, robustness tests are carried out to further scrutinize the models and the underlying data.

## 5.4. Robustness of Results

To test whether the assumptions stated for the different regression models are easily violated, several robustness checks are carried out to examine the robustness and validity of the initial results.

Even though most academic literature applies metropolitan areas or commuting zones as geographical areas, few papers apply municipalities (cf. Eriksson et al., 2017), which can arguably provide a more detailed and less geographically aggregated view on regional employment growth. Accordingly, the original models of this paper have also been analyzed with municipalities rather than commuting zones. However, these regression results do not differ dramatically from the commuting zone results (Appendix 14). Specialization remains strongly significant and positively associated with employment, while competition stays negative and strongly significant. The only change is the slightly significant diversification variable becomes insignificant in the 37-industry data set. Hence, there is no longer any evidence of Jacobs externalities.

In his book *Triumph of the City*, Glaeser (2011) argues that house prices are important determinants for attracting new citizens and, for this reason, allowing cities to thrive. More specifically, he argues that “Chicago succeeds by offering the benefits of density while still remaining affordable and pleasant” (Glaeser, 2011, p. 242). By continuously constructing new buildings, cities – such as Chicago and Houston – have managed to keep house prices relatively affordable compared to expensive cities – such as New York and Los Angeles. Therefore, have cities like Chicago stayed attractive for people with an average income (Ibid.). Because of house prices effect on regional attractiveness, of house prices might be expected to be related to regional employment growth. When including house prices as a control variable, however, the results do not change, and house prices are insignificant throughout all the regression models (Appendix 14). One reason might be that some of the effects that house prices potentially could detect have already captured by other control variables such as education or income.

Due to a relatively high correlation between some control variables, a certain degree of imperfect multicollinearity is expected. Therefore, the regression models have also been run without the residents and average income variables to detect and accommodate the effects of possible multicollinearity. Excluding these two control variables do not change the direction nor the significance of the results (Appendix 15). Hence, the potential of imperfect multicollinearity bias does not affect the initial results.

In addition to the control variables, the data has been examined for outliers. As seen in Table 9 and Appendix 5 and 6, potential outliers have been identified in the specialization variable. To test for the effect of these, all CZ-industries with a specialization variable above 14 have been omitted from Models I, III, and IV, where the median of specialization is approximately 1.00. Accordingly, two CZ-industries have been excluded from each of these models. Despite the coefficient of specialization attaining a stronger positive correlation in the models and similarly for diversification in Model I, the results are virtually the same as in the initial results (Appendix 16). Thus, the results do not appear to be driven by influential outliers.

Lastly, differences in growth rates might also be an important parameter when conducting employment policy. These possible differences in slopes of employment growth could be detected by applying first differenced variables rather than leveled ones. Hence, all models have been run with first differenced CZ-industry employment and control variables. Again, the results do not change considerably from the original models (Appendix 17). The only difference is that the diversification variable becomes significant for the Model II rather than Model I.

Overall, the results of the original models appear robust and valid. They do not change markedly when changing the geographical aggregation, control variables, omitting potential outliers, or taking first differences. Hence, the original models are deemed appropriate for a further discussion of the implications of these results.

## 5.5. Sub-Conclusion

Overall, the results of this analysis indicate the existence of MAR externalities in Danish commuting zones and partly support the arguments of Porter and Jacobs. Particularly, specialization of industries is shown to be significant and positively associated with regional industry employment. Competition is significant and negatively related to regional industry employment, while the diversification variable has a positive and slightly significant association with employment for the 37-industry data set. Consequently, hypotheses H1 and H2 are both rejected, since specialization is positively and competition is negatively related to employment. Meanwhile, hypothesis H3 cannot be rejected given some evidence of diversification in Model I and insignificance in the remaining models. The strong results of specialization are similar for high- and low-tech industries, where the specialization effect is slightly stronger for low- rather than high-tech industries. Hence, hypotheses H4 and H5 cannot be rejected. The reliability of these findings is further substantiated by all models having a relatively high predictive power ranging from 0.46 to 0.88, in line with other empirical findings. Lastly, several robustness checks show that the results do not change dramatically, which underlines the validity of the models.

In the following section, these findings are discussed, and implications are drawn for policymakers and firms on how to engender employment in the Danish regions according to the results of this paper.

# 6. Discussion

This section discusses the findings of the paper along with its implications. Firstly, the analysis serves as support for the general literature base on dynamic externalities. However, the results obtained from Danish regions differ from what has mainly been observed in other studies. Therefore, this section will serve as a discussion of the explanations for why these different relationships hold in Denmark, and what it means for the empirical literature and theory. Secondly, this analysis offers important insights for both policymakers and firm managers in what has characterized employment growth after the financial crisis in Denmark. Consequently, these stakeholders may respond to these relationships by implementing reasonable policies and business strategies that embrace the identified relationships. Here, three explicit policy recommendations are proposed for politicians to enhance regional employment, while considerations for executives are outlined. Lastly, the central limitations of this study are presented.

## 6.1. Theoretical Implications

The results of this paper have important implications for theory, which are discussed in this section. Hereunder, what relationships the theories predict, which theories apply to Danish regions, and why these results are different from some of the empirical literature. As indicated in Table 13, the relationships in Denmark seem to be in support of MAR externalities while providing mixed results for Porter, Jacobs, and SGM.

**Table 13**: Theoretical Predictions and Results from Denmark

| Theory | Specialization | Competition | Diversification |
|---|---|---|---|
| **MAR** | + | – | 0 |
| **Porter** | + | + | 0 |
| **Jacobs** | 0 | + | + |
| **SGM** | 0 | + / – | 0 |

**Source**: Author's creation

In this table, the green boxes indicate a correct prediction of the theory on Danish regions, the yellow boxes indicate mixed results, while the red boxes indicate opposing results to the theory. As evident from Table 13, specialization and diversification are positively related to employment, whereas competition is negatively associated with employment. One reason for this departure from empirics and theoretical predictions is that Denmark applies the universal welfare model, which includes a large public sector. Further, the findings might suggest that firms have become too small, and competition has become too fierce in Denmark. Why these effects are at play in Denmark – in contrast to other countries – is now discussed in detail.

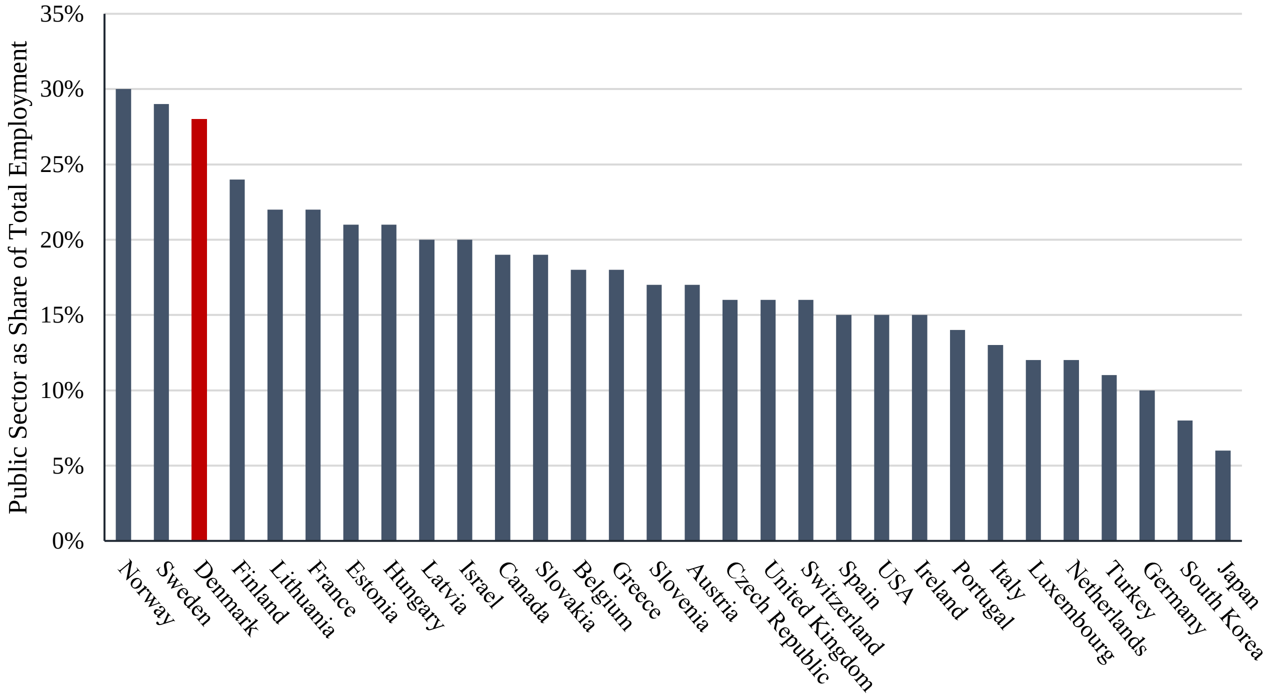
### 6.1.1. Industrial Specialization

As evident in Table 13, the regression models indicate that specialization of industries is positively related to employment growth in Danish regions, in line with the concepts of MAR and Porter. Although some evidence implies that industrial diversification is also associated with regional growth in Denmark, it is not as strongly evident as specialization in the models above. These findings suggest that regardless of being a high- or low-tech industry, specialization is related to employment growth. In these two sectors, Jacobs' argument of diversification has no significant effects. Accordingly, MAR and Porter's theories on specialization are better capable of explaining the Danish local labor market from 2008 to 2019. To this effect, geographical concentration facilitates knowledge spillovers within an industry to foster location-specific knowledge and, ultimately, enhances regional employment growth in Denmark. As such, the findings differ from other empirical work, as much literature finds evidence of Jacobs externalities. Some potential explanations of this divergence might be connected to institutional and structural differences between Denmark and the country of reference in other studies.

Glaeser and colleagues (1992) – along with Feldman and Audretsch (1999) – find strong evidence that diversification promotes knowledge spillovers and, thereby, encourages regional growth among US city-industries. This is also the evidence in most studies of Europe. However, this finding is not as strongly pronounced in the results from this study, where some of this discrepancy can be explained by the large public sector of Denmark compared to the US and many other European countries. As seen in Table 7, industries like social institutions and education are consistently among the largest industries for most regions. Since this paper analyzes the six largest industries in each region, these public sector industries will inevitably play a considerable role. Accordingly, it is not controversial to expect that the rather specialized public sector is the predominant driver of employment growth in the regression models.

Thus, an exclusion of the public sector may be motivated to focus on the knowledge spillovers within the private sector, which is more closely related to a market-driven economy like the US. However, the sheer size of the public sector does not warrant such exclusion and would underestimate the importance of the Danish welfare model, since more than 28% of the Danish workforce is employed within the public sector (Graph 6). Nonetheless, the industries of public administration, education, and human health activities – among others – are not included in the high- and low-tech data sets, as the regressions focus on high-tech manufacturing and service industries relative to the low-tech ones (Appendix 3). The exclusion, however, shows no marked differences in the importance of specialization on regional employment growth, although it remains relatively more relevant among the low-tech industries compared to the high-tech ones. This finding further underlines the robustness of the results.

**Graph 6**: Public Sector as Share of Total Employment in 2017




**Source**: Author's creation with data from Hansen (2020)

The sample period of the data is another potential explanation of the diverging findings. With data from 2008 to 2019, this data is relatively more recent compared to other studies within dynamic externalities, which have focused primarily on the second half of the 20$^{th}$ century and the pre-financial crisis period. Accordingly, the data sets applied in this paper concern an economy relatively more dominated by the service sector rather than the primary and secondary sectors, as Graph 2 depicts. This structural change in the economy indicates that the service industry is maybe more likely to locate in a cluster of similar services. For example, consulting, education, travel agencies, and other services have experienced quite substantial employment growth in larger commuting zones (Table 6). Consequently, the underlying nature of the data might explain why there is stronger evidence of specialization as opposed to diversification.

The education system in Denmark can also justify the relatively more pronounced evidence of specialization. The Danish system is more industry-focused compared to more general-oriented education systems such as the US one (Hall & Soskice, 2001). With a focus on industry-specific educational training rather than a higher focus on general skills, Denmark may institutionally favor intra-industry knowledge spillovers. The US and UK systems, on the other hand, arguably promote inter-industry knowledge spillovers. Here, employees may be more compelled to use their general skills and diverse backgrounds in a mix of industries, in accordance with Jacobs externalities. Thus, it seems plausible that the Danish education system carries some weight in the positive and significant findings on specialization and only weak significance of diversification related to employment.

Besides the institutional and structural environment of Denmark, another reason for the relatively stronger evidence of specialization can be attributed to the static externalities at play. For example, firms may locate close to suppliers to save transportation costs. With a sample that predominantly includes large and mature industries rather than new ones, the analysis does not reject that localization may still be related to regional specialization, which is also remarked by Glaeser and colleagues (1992). Moreover, urbanization may prevail as another static externality that explains the development of local demand. It is not controversial to expect that much of the employment growth in Denmark is driven by the larger cities of Copenhagen and Aarhus, since demand will inevitably be higher in these regions. Nonetheless, the regression models control for the number of residents, whereby the effect of urbanization is moderately proxied in the models.

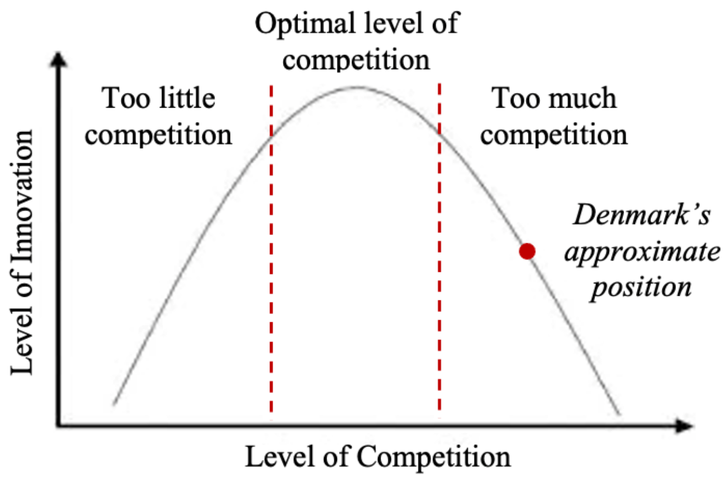
With the findings on specialization diverging from some other researchers' outcomes, the reasons are potentially explained by the Danish institutional environment along with the data sampling. These possible explanations also prevail when discussing the nature of competition in the Danish labor market.

### 6.1.2. Evidence of an Inverted-U Relationship?

Contrary to what Porter and Jacobs argue, the results of this paper indicate that fiercer competition is negatively associated with employment. Only MAR expects this negative relationship. Hence, this theory seems to be most precise in describing the competition mechanisms in the Danish labor market, whereby this paper's result diverges from the findings in various academic studies (cf. Glaeser et al., 1992; Feldman & Audretsch, 1999; Frenken et al., 2007). These papers have mainly supported fiercer competition in improving employment growth. There are several reasons, however, why this deviation is the case.

Firstly, the initial level of competition in Danish industries may simply be too high and competition must decrease to reach an optimal level of competition. This notion is in line with the argument from the SGM and the findings of Jespersen (2003). The SGM states that countries and industries should strive for an optimal level of competition that is neither perfect competition nor monopoly, but rather something in between (Aghion et al., 2015). Applying this inverted-U shape relationship to the Danish labor market, the negative relationship of the competition variable indicates that Denmark has moved past the optimal level and has become too competitive (Graph 7). Therefore, a decrease in competition will possibly allow the larger firms to capture a bigger share of their own R&D investments themselves and, thus, increase their incentive for investments. This increase in investment and innovation would then increase industry employment, according to the SGM.

**Graph 7**: The Inverted-U Relationship of Competition and Innovation in Denmark




**Source:** Author's creation

Secondly, in line with the SGM and the inverted-U relationship, Denmark has a relatively large share of smaller businesses compared to other countries. For example, the otherwise relatively similar country of Sweden has an industry structure consisting of a greater share of large firms (Eriksson et al., 2017). Because of this fundamental difference in national industry structure, competition is considered relatively more intense in Denmark due to the larger number of businesses for each industry. Thus, Sweden might be comparatively closer to the optimal level of competition than Denmark, assuming that Sweden does not have too little competition. Consequently, Denmark's large share of smaller businesses can partly explain the negative correlation of competition with regional industry employment.

Lastly, similar to industrial specialization, the Danish universal welfare model is also expected to affect competition within regional industries, as the public sector is relatively big and will ultimately drive a large proportion of jobs created. As indicated in Graph 6, the public sector accounts for a sizeable proportion of total employment. In contrast to Denmark, other countries – such as the US, England, and Germany – apply a very different welfare model, either the residual welfare model or the selective welfare model, which both include a smaller public sector. Hence, the results in such countries are conceivably driven less by the public sector and instead by the intuitively more competition-driven private sector. This difference in welfare models might explain part of the difference in results between academics.

Overall, these are some plausible reasons that competition is negatively associated with regional industry employment in Denmark, while the relationship is positive in many other countries. With these theoretical implications in mind, it is furthermore viable to assess the practical implications of the results.

## 6.2. Implications for Policymakers and Firms

Besides implications for theory, the results of this paper are of great relevance both for policymakers and firm managers. From a political perspective, these results are important, since an increase in local employment would increase tax income while decreasing public spending, all else equal. Therefore, this paper provides politicians with three general recommendations to enhance local employment. Firstly, a tax break on R&D spending would incentivize firms to increase spending on innovation activities. Secondly, by securing optimal conditions for cluster development, regions would allow existing clusters to prosper and, thereby, drive future employment growth. Lastly, by improving general amenities, the region would become more attractive for firms and employees. For firm managers, on the other hand, these results are useful in potentially supplementing the profitability of firms and their ability to innovate.

### 6.2.1. Promoting MAR Externalities

The relatively strong results of MAR externalities on growth among Danish regions are highly relevant from a policymaking perspective. As suggested by the regression results above, specialization and less fierce competition largely explain the regional industry employment. This can be translated to either attracting more workers from other regions or converting unemployed people to employed workers. The latter is of particular relevance for policymakers, as unemployment benefits and loss of skills among jobseekers are significant burdens to the public finances (Ljungqvist & Sargent, 1998). For this reason, three policy recommendation are provided.

Firstly, one way to incentivize knowledge spillovers among firms is by subsidizing R&D spending through a national policy and, thereby, enhancing regional employment growth. Therefore, the first recommendation is proposed:

*Recommendation 1 (R1): Nationally subsidize R&D spending through tax breaks to incentivize innovation.*

Bloom, Shankerman, and Van Reenen’s (2013) find that fiercer competition – through business stealing of R&D initiatives – negatively affects innovation to be socially sub-optimal. Similarly, the data of this project – in combination with SGM theory – suggest that there is too much competition within CZ-industries. As a result, companies will invest too little in R&D activities, since companies fear that innovations will be partly appropriated by competitors without due compensation. This notion is a concern that can also be linked to MAR externalities.

Hence, subsidizing companies' R&D spending – for example, through tax breaks – is likely to increase the investment in R&D and, ultimately, human capital and regional growth. It is important that such policy is implemented on a national level rather than a regional one, since a small push strategy – for example, attracting business through subsidization or tax cuts on a local level – may lead to bidding wars among municipalities and a net loss to the Danish economy (cf. Moretti, 2013).

Secondly, the evidence of specialization also implies that regions should aim policies at attracting employees and firms from related industries, which leads to this paper's second policy recommendation:

*Recommendation 2 (R2): Policymakers should implement policies aimed at engendering general cluster development.*

This recommendation aligns well with Porter's (1998) theory on clusters, where he argues that the government is to play an active role in engendering cluster development. To this extent, policymakers can set up an institutional environment allowing firms to cooperate on R&D – for example, through suitable intellectual property rights. This will thereby enable the development of clusters, rather than policymakers choosing desirable industries. Instead of abandoning certain industries that the government believes are failing, the government should support these clusters due to their positive effect on other industries within the region. This aligns with the regional path dependency proposed by Neffke and colleagues (2011) and the impediment suggested by Moretti (2013). According to them, governments are generally unable to create new clusters from scratch, as such creation is largely up to market forces. Instead, the role of the government is tied to initiatives furthering "highly specialized skills and knowledge" as well as promoting geographic proximity of related companies (Porter, 1998, p. 90).

It is furthermore important to note that the positive and significant coefficient of specialization does not imply that all commuting zones should be specialized in the same industry. If this is overlooked, the specialization effect would cancel out. Ideally, policymakers should largely refrain from attempting to pick winners and losers, as argued by Moretti (2013), Greunz (2003), and Andersen, Bentzen, Nannarup, Smith, and Westergård-Nielsen (2016). Here, Moretti (2013) highlights that even hedge funds and venture capitalists find it difficult to identify the right firms and industries, which is likely as difficult for policymakers. Thus, it is more appropriate for regions to enable growth through general policies beneficial for all industries.

For example, policies in Svendborg are to engender specialization in prefabricated facade elements in wood, Billund in toy manufacturing, and Grenå in producing fighter jets and combat ship equipment. It is imperative, however, that these policies should not harm other industries as a result. There are certain industries where this is not as clear-cut, given that all regions require certain services. For example, Arla has spread its production to several facilities around Denmark, since it logistically makes more sense for Arla to have three large production sites, as they have to deliver milk every morning (Arla, n.d.). Consequently, a region is to enable specialization of industries while not favoring any particular one, which leads to the second recommendation of this paper:

A final advice is for regions to ensure a decent level of general amenities, as proposed in the third recommendation:

*Recommendation 3 (R3): Policymakers should ensure relevant and sufficient amenities to foster regional attractiveness for both employees and firms.*

Here, a certain level of key amenities will arguably create the foundation for enabling industrial specialization by workers wanting to live and work in a region. In accordance with Jespersen (2003) and Glaeser (2011), this study also finds a positive and strongly significant relationship between education and employment, when removing other controls in Appendix 15. Thus, ensuring good schooling and educating more people is vital for attracting workers and stimulate regional growth. Moreover, this argument can be extended to the attraction of young, well-educated families, which will further increase local demand for goods and services through the multiplication effect in line with Moretti (2013).

Furthermore, the attractiveness of regions is also reliant on the crime rate, as argued by Glaeser (2011). He specifies that people with high levels of education are more willing to settle in regions with safe streets and high-quality schools. However, his argument is based on cities such as Detroit and Paris, whereas Denmark is relatively safer, as indicated by the five times lower murder rate in Denmark compared to the US (Nørtoft & Hohnen, 2020). Nonetheless, the argument still holds in terms of regional attractiveness, where some Danish regions might find justification for this argument.

Aside from education and safety, an apt transportation system is another amenity that increases the appeal of a commuting zone through better mobility within and across regions. This amenity is especially relevant when considering the decreasing number of commuting zones, whereby facilitating a well-connected transportation system is crucial in attracting more employees. In line with the infrastructure plan *Denmark Forward* proposed by the Danish Ministry of Transportation, Duranton and Turner (2012) find that increasing a US city's stock of highways by 10% is related to a 1.5% increase in employment growth. Thus, it is both favorable and important to improve the mobility of people and ideas, as knowledge is key in engendering knowledge spillovers. As argued by Glaeser (2013), "people and businesses typically choose a location because of proximity," where policies to diminish transportation costs of people and ideas are means to foster employment growth. For example, the commuting zone of Grenå encouraged the endeavors of the transport manufacturing industry by adding an extra local train station near Terma's factory and improving the conditions of the nearby airport, Tirstrup airport

(Andersen, 2021). This amenity will arguably help enable Terma to attract and retain employees while not harming other industries in the municipality.

Accordingly, it is vital that policymakers establish amenities – such as good schooling, safe streets, and well-connected transportation systems – to ensure that regions become or remain attractive for possible workers and firms, which leads to this paper's third policy recommendation.

Lastly, it is important to remark that regions are heterogeneous. Broadly speaking, *one size does not fit all* in policymaking, whereby the above policy advice may not be relevant for all regions. Instead, these recommendations are based on the regression results, which indicate average estimates for the industry structures that through dynamic externalities enhance regional growth. Since this study's evidence suggests that specialization is consistently and largely explanatory of employment growth, on average, a region solely focusing on increasing specialization may miss the target. As argued by Tödtling and Trippl (2005), the recommendations should follow some precaution, as the suggestions must be adapted to a region, since there is no ideal policy model that suits all geographical areas within a country. Similarly, since much policy on the matter of industrial structures is decentralized, it is key to adapt the recommendations to the particular conditions of the region in question.

### 6.2.2. Strategic Localization of Firms

In addition to political implications, the findings of this paper are also of relevance to firm managers. Due to the positive and strongly significant relation between specialization and employment, this arguably also affects strategic decisions made by firms and, ultimately, their profits. Further, since employment growth is used as a proxy for regional economic growth, companies locating in specialized regions will have better conditions for achieving this growth, all else equal. Hence, firms need to consider the importance of regional specialization effects when locating their businesses.

A specialized region arguably seems more attractive to firms than a non-specialized region, since it allows firms access to a talented local pool of knowledge, which may otherwise be inaccessible to the firm. Especially for startups, such knowledge spillovers are important, as industry knowledge and expertise are critical in the early phases of a company's lifetime (Seth, 2019). Similarly, industrial clusters often include competitors, supporting industries, and universities which reinforces the local pool of knowledge and the attractiveness of a region. This effect of specialized industrial knowledge may be the reason why such a high concentration of robotics startups locates in Odense. Specifically, the robotics cluster in Odense has collaborated with the local university, the University of Southern Denmark (SDU). In 2017, SDU created a study program for engineers specialized in robotics, as the local robotics industry lacked sufficient labor (Kvistgaard, 2017). Hence, the presence of a university specialized in robotics provides a competitive advantage for the robotic firms located in Odense compared to firms located in other regions of Denmark.

In addition to the pool of knowledge, firms located in specialized regions also benefit from the presence of supporting industries such as a deep and specialized supplier base. Higher proximity of these supporting industries improves communication and allows for better information sharing across the entire supply chain, which would help to minimize inventory, waste, and lead times. The benefits of close relationships with partners in a cluster are emphasized by Porter (1998, p. 81), who argues that "the close, informal relationships possible among companies in a cluster are often a superior arrangement." Thus, as pointed out by Porter, the productivity advantages of geographical proximity can be significant and are important to consider as a firm.

Lastly, another important aspect for firms is the collaboration between the public sector and private firms. Previously, executives primarily thought about this relationship in terms of lobbying the government for their own benefit (Porter, 1998). However, corporations may significantly benefit from collaboration with the government and the municipality. Investments made in the public sector, such as improved infrastructure or education, can significantly improve a firm's productivity (Ibid.). For example, both Terma and Grenå municipality have benefitted from the decision to include an extra local train station close to Terma's offices. Realizing this, managers should seek to find mutually beneficial agreements with governments and public institutions to enhance the overall productivity of the firm and the supporting cluster.

Overall, firm managers are advised to think about specialization when locating their businesses, since it can have positive effects on their bottom line. As Moretti (2013, p. 144) argues, "larger clusters are more efficient because they have a thicker labor market, a more specialized supply of business services, and more opportunities for knowledge spillovers." Hence, joining a larger cluster can be beneficial to a firm in several ways. Even though locating in a specialized region might be valuable to a firm, it cannot by itself make unprofitable firm profitable.

## 6.3. Limitations

While the findings of this paper are relevant for both policymakers and firms, the study is subject to some limitations. In particular, the main constraints of the results and implications concern the industry-level aggregation and regional heterogeneity, along with the difficulty of policy implementation.

Beaudry and Schiffauerova (2009) find that it is generally not the geographical location nor the choice of time-period that affect the results of studies the most. Rather, it is the choice of method that drives the differences in results in the academic literature on dynamic externalities. More specifically, it is the level of industrial and geographical aggregation. For this reason, the limitations of Statistics Denmark's data on one- and two-digit industry-level employment and the number of firms might influence the results of this paper. While several robustness checks have been carried out, the constraint of industry levels remains and hinders particularly the inferences on competition for industries aggregated in 11 groups.

Additionally, the feasibility of the recommendations is constrained by regional differences and the game of politics. Even though Denmark is a relatively small and homogeneous country, there are certain differences between regions regarding employment, income, industry structure, and demography, among others, which cannot be ignored (Risager, 2021). Although this paper accommodates this issue partly by using commuting zones rather than municipalities, there will be inevitable differences between these. Therefore, another limitation to this paper is that regions will be different in one way or another, and some policies applied in one region may not achieve the desired results in another. This fact emphasizes the importance of local knowledge and insight when conducting employment policy on a local level, as emphasized by Monsson (2014). However, the feasibility of the recommendations is also liable to the complex political scene, in which policymakers consider the voters' opinions, budget for the public sector, and reach compromises. Therefore, implementing these recommendations is not straightforward, as employment in certain public sectors is bounded by national and regional negotiations for the distribution of public investments.

Recognizing these shortcomings, the findings and implications remain valid, since these limitations do not fundamentally impede the evidence of the strong relationship between industrial specialization and regional growth in Denmark following the years after the financial crisis.

## 6.4. Sub-Conclusion

This section of the paper has discussed why MAR is the most fitting theory in explaining the industrial relationships within Danish regions. Explanations for this result have been discussed, including the fact that Denmark applies a universal welfare model, which includes a larger public sector than other models and implies more specialization and less competition. Further, Denmark has a relatively more specialized education system than many other countries, which ultimately facilitates a higher degree of specialization in Denmark. Moreover, the Danish industrial landscape is characterized by a large proportion of small businesses, which suggests that fierce competition is anticipated. Here, the SGM suggests that Denmark has moved beyond the optimal level of competition.

In addition to the theoretical implications, there are also a number of important consequences for policymakers and firm managers. Politicians need to be aware of how to facilitate employment growth to improve and optimize public finances. More specifically, policymakers are recommended to; 1) subsidize R&D spending through tax breaks on innovation, 2) enable local cluster development, and 3) improve the level of general amenities such as schooling, transportation, and safety. By implementing these suggestions, it is argued that the Danish regions can improve employment levels. However, it is important to bear in mind that one policy does not fit all regions. Hence, the local politicians should analyze the industrial environment and apply policies suitable to their specific geographical area. In addition to the implications for policymakers, the finding of this paper is of relevance for firm managers, as they can enhance their chance of success by considering the effects of localization and dynamic externalities.

By the nature of this study, there are some limitations. The most important limitation of this study – as addressed by Beaudry and Schiffauerova (2009) – is the fact that the local industries are aggregated at a moderately high level. However, with the thorough application of econometric methods, it is still believed that this paper provides significant implications and adds an important contribution to the current literature base.

# 7. Conclusion

This paper has investigated the relationship between industry structures and regional growth in Denmark after the financial crisis. It is concluded that industrial specialization and less fierce competition are strongly related to regional employment growth in Denmark. Accordingly, MAR externalities appear to be the best theory at explaining regional employment growth in Denmark, while the results only partly support Porter and Jacobs. The partial support of Jacobs is attributed to the weak evidence of industrial diversification. For the high- and low-tech industries, specialization is also the main driver of employment, in accordance with the overall results. The effect of specialization, however, is somewhat stronger for low-tech industries compared to high-tech industries, indicating that specialization is more essential within low-tech industries. With the high explanatory power of the regression models along with the robustness checks carried out, the results remain both strong and valid.

To identify the drivers of regional growth among 29 Danish commuting zones from 2008 to 2019, five hypotheses have been tested through econometric analysis, using employment as a proxy for regional growth. Following several econometric tests, a fixed effects regression model with clustered standard errors has been identified as the most optimal model for the longitudinal data set. In line with economic theory and reasoning, the models control for education, number of residents, average income, and national industry employment.

While the findings on the industry structure of Denmark support MAR externalities, many other researchers have commonly found evidence supporting Jacobs externalities. One of the reasons why the results on Danish regions depart from much academic literature is that Denmark applies a different welfare model than most countries. With a universal welfare model, Denmark has a relatively large public sector, which therefore accounts for a relatively large share of job creation. In this instance, the public sector will have a larger degree of specialization and a lesser degree of competition than the private sector, all else equal. Thus, the results will tend towards MAR rather than Jacobs externalities. Another major reason for the evidence of specialization in Denmark lies in the specialized education system. Compared to Anglo-Saxon countries, Denmark's education system is relatively more specialized, as students are somewhat tailored for specific industries compared to education systems with a higher focus on generalized skills. Additionally, Denmark is characterized by a relatively large degree of smaller firms than in many other countries. Therefore, according to the SGM, it seems that the level of competition is too fierce in Denmark and that a lessening of competition would improve innovation conditions overall.

In addition to the theoretical implications, this paper's findings are of relevance to policymakers. This study has shed light on which industry structures have been most beneficial in creating jobs in regional industries in Denmark since the financial crisis. Thus, the results give some suggestions for policymakers in shaping policies that enhance tax revenue while decreasing public spending on unemployment benefits. Based on these results, policymakers are provided with three specific recommendations. They are advised to; 1) increase firms' incentive to innovate by decreasing the tax level on R&D activities, 2) implement policies that improve conditions for general cluster development, and 3) improve the level of general amenities to increase the attractiveness of the region. If implemented correctly, these three recommendations are believed to improve the conditions for regional job creation and for clusters to prosper. However, it is vital for policymakers to keep in mind that these findings and recommendations are aimed at the median commuting zone. Accordingly, the regional heterogeneity must be considered when implementing the recommendations of this paper. The current aim of a *cohesive Denmark* expressed by the government, the infrastructure investments, and the Ministry of Education and Research's endeavors to promote cluster development are thus promising steps in the right direction. However, there is room for improvement in encouraging R&D investments nationally and refraining from favoring certain industries.

Additionally, the results of this paper are also of relevance for firm managers. Business executives – and particularly shareholders – care about profits. Dynamic externalities can greatly affect profits, and the location advantages can be significant, for which reason these should not be ignored. In a specialized region, a firm has access to a specialized local pool of knowledge, a specialized supplier base, and a supporting public sector. All these benefits can potentially help the firm to innovate, grow, and create additional jobs. Therefore, firm executives and owners must carefully consider the effects of knowledge spillovers when locating their businesses.

### Future Research

The question of what drives regional growth is still very relevant, as a number of questions remain to be addressed. This study has only investigated this question from one of several important angles, namely employment. Hence, investigating this issue from another angle – such as productivity – might also reveal interesting results. In addition, this study has encountered a number of data-related barriers, such as industry aggregation. Therefore, if possible, it would be of great relevance to apply the same model with more granular industry data – for example, three-digit industry NACE codes – to unfold potential discoveries herein. Further, it would also be meaningful to test these theories of dynamic externalities in neighboring countries, to see if similar relationships hold in these countries after the financial crisis. Lastly, examining the causality of this paper's results is another area for future research. With reference to previous empirics, few researchers address and investigate the issues of causality, whereby insights in this particular area are scarce and, thus, considerably relevant. Hence, several topics need further investigation within the research of dynamic externalities.

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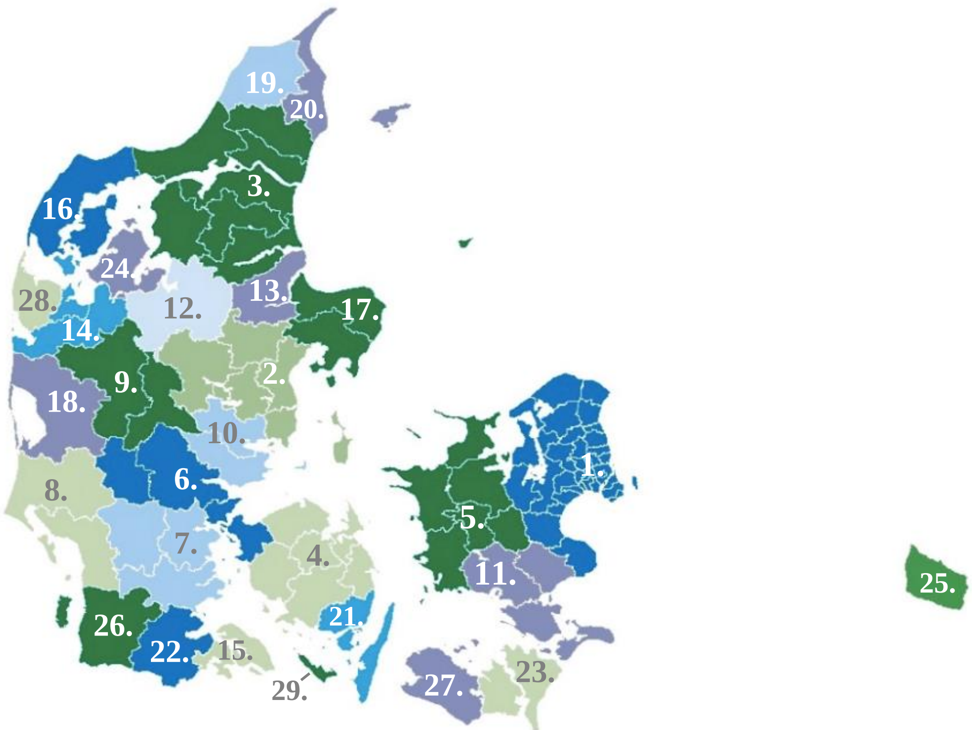
# 9. Appendices

## Table of Content for the Appendices

## Appendix 1: Commuting Zones in Denmark




| | | | | | |
|---|---|---|---|---|---|
| **1.** | København | **11.** | Næstved | **21.** | Svendborg |
| **2.** | Aarhus | **12.** | Viborg | **22.** | Aabenraa |
| **3.** | Aalborg | **13.** | Randers | **23.** | Nykøbing F |
| **4.** | Odense | **14.** | Holstebro | **24.** | Skive |
| **5.** | Slagelse og Holbæk | **15.** | Sønderborg | **25.** | Bornholm |
| **6.** | Vejle og Fredericia | **16.** | Thisted og Nykøbing M | **26.** | Tønder |
| **7.** | Kolding | **17.** | Grenaa | **27.** | Nakskov |
| **8.** | Esbjerg | **18.** | Ringkøbing og Skjern | **28.** | Lemvig |
| **9.** | Herning | **19.** | Hjørring | **29.** | Ærø |
| **10.** | Horsens | **20.** | Frederikshavn | | |

**Source**: Adapted from Thorsen, Andersen, and Holm (2016)

## Appendix 2: Overview of Statistics Denmark’s 10- and 37-Industry Groupings

| 11-Industry Group | 37-Industry Group |
|---|---|
| 1 Agriculture, forestry, and fishing | A Agriculture, forestry, and fishing |
| 2 Industry, raw material extraction and utility companies | B Raw material extraction<br>CA Food, beverage, and tobacco industry<br>CB Textile and leather industry<br>CC Wood and paper industry, printing plants<br>CD Oil refineries etc.<br>CE Chemical industry<br>CF Pharmaceutical industry<br>CG Plastics, glass, and concrete industry<br>CH Metal industry<br>CI Electronics Industry<br>CJ Production of electrical equipment<br>CK Mechanical engineering industry<br>CL Vehicle manufacturing industry<br>CM Furniture and other industry etc.<br>D Energy supply<br>E Water supply and renovation |
| 3 Building and construction | F Building and construction |
| 4 Trade and transport, etc. | G Trade<br>H Transportation<br>I Hotels and restaurants |
| 5 Information and communication | JA Publishers, TV, and radio<br>JB Telecommunications<br>JC IT and information services |
| 6 Financing and insurance | K Financing and insurance |
| 7 Real estate and rental | L Real estate and rental |
| 8 Business services | MA Consulting etc.<br>MB Research and development<br>MC Advertising and other business services<br>N Travel agencies, cleaning, and other operational services |
| 9 Public administration, education, and health | O Public administration, defense, and police<br>P Education<br>QA Healthcare<br>QB Social institutions |
| 10 Culture, leisure, and other services | R Culture and leisure<br>S Other services, etc. |
| 11 Undisclosed activity | X Undisclosed activity |

**Source**: Translated from Statistics Denmark (Torma, Simbold, Sørensen, Madsen, & Skjelbo, 2015).

## Appendix 3: Eurostat Indicators on High- and Low-Tech Industry and Knowledge Intensive Services

| Manufacturing Industries | NACE Rev. 2 codes – 2-digit level | |
|---|---|---|
| **High-technology** | 21 | Manufacture of basic pharmaceutical products and pharmaceutical preparations; |
| | 26 | Manufacture of computer, electronic and optical products |
| **Medium-high-technology** | 20 | Manufacture of chemicals and chemical products; |
| | 27 to 30 | Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c. ; Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment |
| **Medium-low-technology** | 19 | Manufacture of coke and refined petroleum products; |
| | 22 to 25 | Manufacture of rubber and plastic products; Manufacture of other non-metallic mineral products; Manufacture of basic metals; Manufacture of fabricated metals products, excepts machinery and equipment; |
| | 33 | Repair and installation of machinery and equipment |
| **Low technology** | 10 to 18 | Manufacture of food products, beverages, tobacco products, textile, wearing apparel, leather and related products, wood and of products of wood, paper and paper products, printing and reproduction of recorded media; |
| | 31 to 32 | Manufacture of furniture; Other manufacturing |

| Knowledge based services | NACE Rev. 2 codes – 2-digit level | |
|---|---|---|
| **Knowledge-intensive services (KIS)** | 50 to 51 | Water transport; Air transport; |
| | 58 to 63 | Publishing activities; Motion picture, video and television programme production, sound recording and music publish activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities (section J); |
| | 64 to 66 | Financial and insurance activities (section K); |
| | 69 to 75 | Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities (section M); |
| | 78 | Employment activities; |
| | 80 | Security and investigation activities; |
| | 84 to 93 | Public administration and defence, compulsory social security (section O); Education (section P), Human health and social work activities (section Q); Arts, entertainment and recreation (section R). |
| **Knowledge-intensive market services (excluding high-tech and financial services)** | 50 to 51 | Water transport; Air transport; |
| | 69 to 71 | Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; |
| | 73 to 74 | Advertising and market research; Other professional, scientific and technical activities; |
| | 78 | Employment activities; |
| | 80 | Security and investigation activities; |
| **High-tech knowledge-intensive services** | 59 to 63 | Motion picture, video and television programme production, sound recording and music publish activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities; |
| | 72 | Scientific research and development; |
| **Knowledge-intensive financial services** | 64 to 66 | Financial and insurance activities (section K). |
| **Other knowledge-intensive services** | 58 | Publishing activities; |
| | 75 | Veterinary activities; |
| | 84 to 93 | Public administration and defence, compulsory social security (section O); Education (section P), Human health and social work activities (section Q); Arts, entertainment and recreation (section R). |

| Knowledge based services | NACE Rev. 2 codes – 2-digit level | |
|---|---|---|
| **Less knowledge-intensive services (LKIS)** | 45 to 47 | Wholesale and retail trade; Repair of motor vehicles and motorcycles (section G); |
| | 49 | Land transport and transport via pipelines; |
| | 52 to 53 | Warehousing and support activities for transportation; Postal and courier activities; |
| | 55 to 56 | Accommodation and food service activities (section I); |
| | 68 | Real estate activities (section L); |
| | 77 | Rental and leasing activities; |
| | 79 | Travel agency, tour operator reservation service and related activities; |
| | 81 | Services to buildings and landscape activities; |
| | 82 | Office administrative, office support and other business support activities; |
| | 94 to 96 | Activities of membership organisation; Repair of computers and personal and household goods; Other personal service activities (section S); |
| | 97 to 99 | Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use (section T); Activities of extraterritorial organisations and bodies (section U). |
| **Less knowledge-intensive market services** | 45 t6 47 | Wholesale and retail trade; Repair of motor vehicles and motorcycles (section G); |
| | 49 | Land transport and transport via pipelines; |
| | 52 | Warehousing and support activities for transportation; |
| | 55 to 56 | Accommodation and food service activities (section I); |
| | 68 | Real estate activities (section L); |
| | 77 | Rental and leasing activities; |
| | 79 | Travel agency, tour operator reservation service and related activities; |
| | 81 | Services to buildings and landscape activities; |
| | 82 | Office administrative, office support and other business support activities; |
| | 95 | Repair of computers and personal and household goods; |
| **Other less knowledge-intensive services** | 53 | Postal and courier activities; |
| | 94 | Activities of membership organisation; |
| | 96 | Other personal service activities; |
| | 97 to 99 | Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use (section T); Activities of extraterritorial organisations and bodies (section U). |

**Source**: Eurostat (2020) on high- and low-tech aggregation by NACE Rev. 2.

## Appendix 4: Variable Characteristics for the Data Set of 11 Industries

**Table**: Variable Characteristics for the Data Set of 11 Industries (2008-2019)

| Variables | Minimum | Median | Mean | Maximum | Std. Dev. |
|---|---|---|---|---|---|
| *Dependent variable* | | | | | |
| CZ-industry Employment | 4.4308 | 8.4364 | 8.4335 | 12.6704 | 1.3483 |
| *Key independent variables* | | | | | |
| Specialization | 0.4270 | 0.9927 | 1.1483 | 4.9495 | 0.5987 |
| Competition | 0.4449 | 1.0407 | 1.1129 | 5.0652 | 0.3010 |
| Diversification | -0.9531 | -0.7492 | -0.7350 | -0.3820 | 0.1197 |
| *Control variables* | | | | | |
| Education (log) | 4.8828 | 7.8326 | 8.0287 | 12.6340 | 1.4694 |
| Residents (log) | 8.7091 | 11.2824 | 11.5011 | 14.5421 | 1.0622 |
| Average Income per Resident (log) | 11.8530 | 12.0939 | 12.0938 | 12.4267 | 0.0937 |
| National Industry Employment (log) | 10.7906 | 12.5945 | 12.4909 | 13.6503 | 0.8473 |

## Appendix 5: Variable Characteristics for the Data Set of 37 Industries (High-Tech)

**Table**: Variable Characteristics for the Data Set of 37 Industries, High-Tech (2008-2019)

| Variables | Minimum | Median | Mean | Maximum | Std. Dev. |
|---|---|---|---|---|---|
| *Dependent variable* | | | | | |
| CZ-industry Employment | 0.6931 | 6.2925 | 6.3150 | 10.9963 | 1.5901 |
| *Key independent variables* | | | | | |
| Specialization | 0.0114 | 0.7407 | 1.3850 | 22.0041 | 2.2943 |
| Diversification | -0.3061 | -0.0793 | -0.0922 | -0.0274 | 0.0469 |
| *Control variables* | | | | | |
| Education (log) | 6.0661 | 7.9807 | 8.2230 | 12.6340 | 1.3924 |
| Residents (log) | 9.9034 | 11.3643 | 11.6618 | 14.5421 | 0.9496 |
| Average Income per Resident (log) | 11.8968 | 12.0997 | 12.1055 | 12.4267 | 0.0873 |
| National Industry Employment (log) | 8.6052 | 10.8361 | 10.4471 | 11.5975 | 0.9282 |

## Appendix 6: Variable Characteristics for the Data Set of 37 Industries (Low-Tech)

**Table**: Variable Characteristics for Data Set of 37 Industries, Low-Tech (2008-2019)

| Variables | Minimum | Median | Mean | Maximum | Std. Dev. |
|---|---|---|---|---|---|
| *Dependent variable* | | | | | |
| CZ-industry Employment | 0.6931 | 6.3172 | 6.1683 | 8.9118 | 1.4223 |
| *Key independent variables* | | | | | |
| Specialization | 0.0201 | 1.1346 | 1.4352 | 14.1265 | 1.3861 |
| Diversification | -0.1857 | -0.0697 | -0.0770 | -0.0185 | 0.0336 |
| *Control variables* | | | | | |
| Education (log) | 6.0661 | 7.9807 | 8.2230 | 12.6340 | 1.3924 |
| Residents (log) | 9.9034 | 11.3643 | 11.6618 | 14.5421 | 0.9496 |
| Average Income per Resident (log) | 11.8968 | 12.0997 | 12.1055 | 12.4267 | 0.0873 |
| National Industry Employment (log) | 6.4184 | 10.2355 | 10.0127 | 10.9138 | 0.7499 |

## Appendix 7: Pearson's Correlation Matrix for Model I-IV

**Table**: Pearson's Correlation Matrix for 37 Industries across Danish Commuting Zones

| | Specialization | Diversification | Education | Residents | Average Income per Resident | National Industry Employment |
|---|---|---|---|---|---|---|
| Specialization | 1.0000 | | | | | |
| Diversification | -0.1785* | 1.0000 | | | | |
| Education | -0.1392* | 0.0753* | 1.0000 | | | |
| Residents | -0.1644* | 0.0919* | 0.9783* | 1.0000 | | |
| Average Income per Resident | -0.0496* | 0.0879* | 0.7740* | 0.7263* | 1.0000 | |
| National Industry Employment | -0.6891* | 0.5494* | 0.1409* | 0.1507* | 0.0832* | 1.0000 |

**Note**: This correlation matrix corresponds to the variables from Model I in Table 11. The asterisk indicates a 0.05 significance level.

**Table**: Pearson's Correlation Matrix for 11 Industries across Danish Commuting Zones

| | Specialization | Competition | Diversification | Education | Residents | Average Income per Resident | National Industry Employment |
|---|---|---|---|---|---|---|---|
| Specialization | 1.0000 | | | | | | |
| Competition | -0.3323 | 1.0000 | | | | | |
| Diversification | -0.1551* | 0.1546* | 1.0000 | | | | |
| Education | -0.1204* | -0.3547* | -0.0728* | 1.0000 | | | |
| Residents | -0.1194* | -0.3903* | -0.0700* | 0.9783* | 1.0000 | | |
| Average Income per Resident | -0.0334 | -0.3639* | -0.1163* | 0.7740* | 0.7263* | 1.0000 | |
| National Industry Employment | -0.5168* | 0.1049 | 0.7309 | 0.0358* | 0.0329 | 0.0347* | 1.0000 |

**Note**: This correlation matrix corresponds to the variables from Model II in Table 11. The asterisk indicates a 0.05 significance level.

**Table**: Pearson's Correlation Matrix for 37 High-Tech Industries and Knowledge-Intensive Services across Danish Commuting Zones

| | Specialization | Diversification | Education | Residents | Average Income per Resident | National Industry Employment |
|---|---|---|---|---|---|---|
| Specialization | 1.0000 | | | | | |
| Diversification | -0.1494* | 1.0000 | | | | |
| Education | -0.0479* | -0.1716* | 1.0000 | | | |
| Residents | -0.0842* | -0.0979* | 0.9816* | 1.0000 | | |
| Average Income per Resident | 0.0394 | -0.2324* | 0.7264* | 0.6568* | 1.0000 | |
| National Industry Employment | -0.3024* | 0.1463* | 0.0180 | 0.0164 | -0.0289 | 1.0000 |

**Note**: This correlation matrix corresponds to the variables from Model III in Table 11. The asterisk indicates a 0.05 significance level.

**Table**: Pearson's Correlation Matrix for 37 Low-Tech Industries and Less Knowledge-Intensive Services across Danish Commuting Zones

| | Specialization | Diversification | Education | Residents | Average Income per Resident | National Industry Employment |
|---|---|---|---|---|---|---|
| Specialization | 1.0000 | | | | | |
| Diversification | -0.2515* | 1.0000 | | | | |
| Education | -0.0878* | 0.3125* | 1.0000 | | | |
| Residents | -0.0584* | 0.2729* | 0.9816* | 1.0000 | | |
| Average Income per Resident | 0.0367 | 0.0611* | 0.7264* | 0.6568* | 1.0000 | |
| National Industry Employment | -0.1724* | 0.1878* | -0.0147 | -0.0161 | -0.0301 | 1.0000 |

**Note**: This correlation matrix corresponds to the variables from Model IV in Table 11. The asterisk indicates a 0.05 significance level.

## Appendix 8: Chow Test for Poolability

| Data Set | Null Hypothesis | F-Statistic | Degrees of Freedom | P-Value | Result |
|---|---|---|---|---|---|
| 37 industries | A pooled model is applicable | 93.3890 | (1038; 870) | 0.0000 | $H_0$ is rejected |
| 11 industries | A pooled model is applicable | 24.8290 | (1211; 696) | 0.0000 | $H_0$ is rejected |
| High-Tech Industries (37 IND) | A pooled model is applicable | 16.7320 | (930; 780) | 0.000 | $H_0$ is rejected |
| Low-Tech Industries (37 IND) | A pooled model is applicable | 32.3570 | (930; 780) | 0.000 | $H_0$ is rejected |

## Appendix 9: Honda Test for Two-Way Effects in Balanced Panels

| Data Set | Null Hypothesis | Test-Statistic | P-Value | Result |
|---|---|---|---|---|
| 37 industries | No entity nor time fixed effects: $H_0$: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ | 75.3550 | 0.0000 | $H_0$ is rejected |
| 11 industries | No entity nor time fixed effects: $H_0$: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ | 81.9820 | 0.0000 | $H_0$ is rejected |
| High-Tech Industries (37 IND) | No entity nor time fixed effects: $H_0$: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ | 64.1340 | 0.0000 | $H_0$ is rejected |
| Low-Tech Industries (37 IND) | No entity nor time fixed effects: $H_0$: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ | 64.9970 | 0.0000 | $H_0$ is rejected |

## Appendix 10: Hausman Test to Determine Fixed or Random Effects

| Data Set | Null Hypothesis | $\chi^2$-Statistic | Degrees of Freedom | P-Value | Result |
|---|---|---|---|---|---|
| 37 industries | No correlation between entity- and time effects with the error term: $E\left(\frac{u_{it}}{X_{it}}\right) = 0$ | 117.680 | 6 | 0.0000 | $H_0$ is rejected |
| 11 industries | No correlation between entity- and time effects with the error term: $E\left(\frac{u_{it}}{X_{it}}\right) = 0$ | 642.9100 | 7 | 0.0000 | $H_0$ is rejected |
| High-Tech Industries (37 IND) | No correlation between entity- and time effects with the error term: $E\left(\frac{u_{it}}{X_{it}}\right) = 0$ | 105.6300 | 6 | 0.0000 | $H_0$ is rejected |
| Low-Tech Industries (37 IND) | No correlation between entity- and time effects with the error term: $E\left(\frac{u_{it}}{X_{it}}\right) = 0$ | 85.8990 | 6 | 0.0000 | $H_0$ is rejected |

## Appendix 11: Breusch-Godfrey/Wooldridge Test for Serial Correlation in Panel Models

| Data Set | Null Hypothesis | $\chi^2$-Statistic | Degrees of Freedom | P-Value | Result |
|---|---|---|---|---|---|
| 37 industries | No serial correlation in idiosyncratic errors | 888.2700 | 12 | 0.0000 | $H_0$ is rejected |
| 11 industries | No serial correlation in idiosyncratic errors | 581.7100 | 11 | 0.0000 | $H_0$ is rejected |
| High-Tech Industries (37 IND) | No serial correlation in idiosyncratic errors | 636.9300 | 12 | 0.0000 | $H_0$ is rejected |
| Low-Tech Industries (37 IND) | No serial correlation in idiosyncratic errors | 609.2200 | 12 | 0.0000 | $H_0$ is rejected |

## Appendix 12: Breusch-Pagan LM Test for Cross-Sectional Dependence in Panels

| Data Set | Null Hypothesis | $\chi^2$-Statistic | Degrees of Freedom | P-Value | Result |
|---|---|---|---|---|---|
| 37 industries | No cross-sectional dependence within entities | 44,992 | 15,051 | 0.0000 | $H_0$ is rejected |
| 11 industries | No cross-sectional dependence within entities | 39,552 | 15,051 | 0.0000 | $H_0$ is rejected |
| High-Tech Industries (37 IND) | No cross-sectional dependence within entities | 39,588 | 12,090 | 0.0000 | $H_0$ is rejected |
| Low-Tech Industries (37 IND) | No cross-sectional dependence within entities | 43,008 | 12,090 | 0.0000 | $H_0$ is rejected |

## Appendix 13: Regression Models Including All Control Variables

**Table**: Fixed effects panel models on employment in Danish commuting zones from 2008 to 2019 including entity- and time fixed effects.

| **Dependent variable** | **CZ-industry Employment (log)** | | | |
|---|---|---|---|---|
| | (I)<br>37 IND | (II)<br>11 IND | (III)<br>37 IND,<br>High-Tech | (IV)<br>37 IND,<br>Low-Tech |
| Specialization | 0.1510***<br>(0.0548) | 0.5101***<br>(0.0726) | 0.4916***<br>(0.1136) | 0.5559***<br>(0.0865) |
| Competition | | -0.2306***<br>(0.0659) | | |
| Diversification | 0.4365*<br>(0.2488) | -0.0167<br>(0.0912) | -2.8628<br>(2.5097) | 1.0620<br>(1.3083) |
| Education (log) | 0.0720<br>(0.0752) | 0.1307***<br>(0.0332) | -0.1159<br>(0.3843) | 0.1817<br>(0.1989) |
| Residents (log) | 0.8210***<br>(0.1948) | 0.8421***<br>(0.2996) | 1.6469<br>(1.1727) | 0.5817<br>(0.8180) |
| Average Income per Resident (log) | 0.5236**<br>(0.2277) | 0.1355<br>(0.0985) | 0.9936<br>(0.7875) | 1.2934***<br>(0.4872) |
| National Industry Employment (log) | 0.8793***<br>(0.1097) | 1.0364***<br>(0.0249) | 1.3571***<br>(0.2275) | 1.3905***<br>(0.2122) |
| Entity Fixed Effects | YES | YES | YES | YES |
| Time Fixed Effects | YES | YES | YES | YES |
| Observations (*N*) | 2,088 | 2,088 | 1,872 | 1,872 |
| $R^2$ | 0.5123 | 0.8890 | 0.5349 | 0.5512 |
| Adjusted $R^2$ | 0.4635 | 0.8778 | 0.4879 | 0.5057 |
| F-statistic | 332.1700***<br>(df = 6; 1,897) | 2,169.5000***<br>(df = 7; 1,896) | 325.7050***<br>(df = 6; 1,699) | 347.7260***<br>(df = 6; 1,699) |

**Note**: The table depicts the four fixed effects panel regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors, which are reported in the parentheses. Notably, Ærø, Tønder, and Aabenraa are omitted from the data in Model III and IV due to no employment in several high- and low-tech industries. Significance levels are indicated by the asterisks with *$p$ < 0.10; **$p$ < 0.05; ***$p$ < 0.01.

## Appendix 14: Regression Models for Municipalities

**Table**: Fixed effects panel models on employment in Danish municipalities from 2008 to 2019 including entity- and time fixed effects.

| **Dependent variable** | **Municipality Industry Employment (log)** | | | |
|---|---|---|---|---|
| | (I)<br>37 IND | (II)<br>37 IND | (III)<br>11 IND | (IV)<br>11 IND |
| Specialization | 0.0854***<br>(0.0100) | 0.0848***<br>(0.0097) | 0.2633***<br>(0.0284) | 0.2695***<br>(0.0330) |
| Competition | | | -0.2371***<br>(0.0426) | -0.2627***<br>(0.0610) |
| Diversification | -0.0020<br>(0.1200) | 0.0318<br>(0.1240) | 0.1319<br>(0.0913) | 0.1288<br>(0.0951) |
| Education (log) | 0.0993*<br>(0.0562) | 0.1247**<br>(0.0605) | 0.0423<br>(0.0316) | 0.0421<br>(0.0306) |
| Residents (log) | 0.8445***<br>(0.1474) | 0.7901***<br>(0.1536) | 0.8980***<br>(0.0909) | 0.9068***<br>(0.0936) |
| Average Income per Resident (log) | -0.4030**<br>(0.1648) | -0.4632***<br>(0.1669) | 0.0279<br>(0.0999) | 0.0362<br>(0.0925) |
| National Industry Employment (log) | 0.0713***<br>(0.0641) | 0.7720***<br>(0.0202) | 1.0830***<br>(0.0307) | 1.0800***<br>(0.0300) |
| House Prices (log) | | 0.0245<br>(0.0202) | | 0.0040<br>(0.0094) |
| Entity Fixed Effects | YES | YES | YES | YES |
| Time Fixed Effects | YES | YES | YES | YES |
| Observations (*N*) | 7,056 | 6,840 | 7,056 | 6,840 |
| $R^2$ | 0.6125 | 0.6216 | 0.7823 | 0.8060 |
| Adjusted $R^2$ | 0.5763 | 0.5861 | 0.7619 | 0.7877 |
| F-statistic | 1,699.7500***<br>(df = 6; 6,451) | 1,467.2800***<br>(df = 7; 6,252) | 3,310.9700***<br>(df = 7; 6,450) | 3,245.5000***<br>(df = 8; 6,251) |

**Note**: The table depicts the four fixed effects panel regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors, which are reported in the parentheses. Significance levels are indicated by the asterisks with $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

## Appendix 15: Regression Models with Less Control Variables

**Table**: Fixed effects panel models on employment in Danish commuting zones from 2008 to 2019 including entity- and time fixed effects. Here, the control variables of number of residents and average income per resident are omitted from the models.

| **Dependent variable** | **CZ-industry Employment (log)** | | | |
|---|---|---|---|---|
| | (I) | (II) | (III) | (IV) |
| | 37 IND | 11 IND | 37 IND, High-Tech | 37 IND, Low-Tech |
| Specialization | 0.1510***<br>(0.0540) | 0.4551***<br>(0.0706) | 0.4908***<br>(0.1137) | 0.5549***<br>(0.0850) |
| Competition | | -0.2826***<br>(0.0665) | | |
| Diversification | 0.5171**<br>(0.2551) | 0.1260<br>(0.0981) | -2.7152<br>(2.5743) | 1.0984<br>(1.1883) |
| Education (log) | 0.3675***<br>(0.0458) | 0.3938***<br>(0.0299) | 0.5182***<br>(0.1968) | 0.4640*<br>(0.2413) |
| National Industry Employment (log) | 0.8931***<br>(0.1095) | 1.0247***<br>(0.0296) | 1.3608***<br>(0.2258) | 1.3902***<br>(0.2135) |
| Entity Fixed Effects | YES | YES | YES | YES |
| Time Fixed Effects | YES | YES | YES | YES |
| Observations (*N*) | 2,088 | 2,088 | 1,872 | 1,872 |
| $R^2$ | 0.4726 | 0.8516 | 0.5303 | 0.5446 |
| Adjusted $R^2$ | 0.4203 | 0.8368 | 0.4834 | 0.4991 |
| F-statistic | 425.3310***<br>(df = 4; 1,899) | 2,177.6400***<br>(df = 5; 1,898) | 480.1690***<br>(df = 4; 1,701) | 508.4690***<br>(df = 4; 1,701) |

**Note**: The table depicts the four fixed effects panel regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors, which are reported in the parentheses. Notably, Ærø, Tønder, and Aabenraa are omitted from the data in Model III and IV due to no employment in several high- and low-tech industries. Significance levels are indicated by the asterisks with **p* < 0.10; ***p* < 0.05; ****p* < 0.01.

## Appendix 16: Regression Models without Outliers

**Table**: Fixed effects panel models on employment in Danish commuting zones from 2008 to 2019 including entity- and time fixed effects, where potential influential outliers are excluded from the models.

| **Dependent variable** | **CZ-industry Employment (log)** | | |
|---|---|---|---|
| | (I) | (III) | (IV) |
| | 37 IND | 37 IND, High-Tech | 37 IND, Low-Tech |
| Specialization | 0.3681*** (0.0570) | 0.6294*** (0.1032) | 0.6663*** (0.0793) |
| Diversification | 0.3068* (0.1765) | -1.8442 (1.9457) | 0.4367 (1.1958) |
| Education (log) | 0.0746 (0.0556) | -0.0327 (0.3889) | 0.1704 (0.1881) |
| Residents (log) | 0.9473*** (0.1473) | 1.6772 (1.0852) | 1.0033 (0.7732) |
| Average Income per Resident (log) | 0.4342** (0.1775) | 1.2713* (0.6678) | 1.0299** (0.4542) |
| National Industry Employment (log) | 0.8861*** (0.0716) | 1.3201*** (0.2022) | 1.2811*** (0.2101) |
| Entity Fixed Effects | YES | YES | YES |
| Time Fixed Effects | YES | YES | YES |
| Observations (*N*) | 2,064 | 1,848 | 1,848 |
| $R^2$ | 0.7625 | 0.6341 | 0.6217 |
| Adjusted $R^2$ | 0.7387 | 0.5970 | 0.5834 |
| F-statistic | 1003.300*** (df = 6; 1,875) | 484.432*** (df = 6; 1,677) | 459.360*** (df = 6; 1,677) |

**Note**: The table depicts the four fixed effects panel regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors (reported in the parentheses). The industry with production of electrical equipment in Sønderborg and the chemical industry in Lemvig have been excluded from Models I and III. The industry of oil refineries etc. in Slagelse and Holbæk as well as the textile and leather industry in Herning have been excluded from Model IV. Significance levels are indicated by the asterisks with $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

## Appendix 17: Regression Models Using First Differences

**Table**: Regression models on employment in Danish commuting zones from 2008 to 2019 using first differences.

| **Dependent variable** | **dCZ-industry Employment (log)** | | | |
|---|---|---|---|---|
| | (I) | (II) | (III) | (IV) |
| | 37 IND | 11 IND | 37 IND, High-Tech | 37 IND, Low-Tech |
| Specialization | 0.0436** (0.0198) | 0.1108*** (0.0329) | 0.1372*** (0.0492) | 0.1148*** (0.0240) |
| Competition | | -0.1269*** (0.0265) | | |
| Diversification | 0.2017 (0.1592) | 0.2123** (0.0300) | -0.0047 (0.8644) | 0.1369 (0.8733) |
| dEducation (log) | -0.0086 (0.0751) | 0.1620*** (0.0573) | 0.3308 (0.3303) | 0.3299 (0.2787) |
| dResidents (log) | 0.9303* (0.5519) | 0.4661 (0.2996) | -1.2617 (1.8386) | -0.1812 (1.8880) |
| dAverage Income per Resident (log) | 0.2106 (0.1479) | 0.2653*** (0.0800) | -0.2083 (0.4233) | -0.1075 (0.4526) |
| dNational Industry Employment (log) | 0.9502*** (0.0817) | 0.9466*** (0.0545) | 0.8588*** (0.2089) | 1.0652*** (0.1720) |
| Observations (*N*) | 1,914 | 1,914 | 1,716 | 1,716 |
| $R^2$ | 0.2327 | 0.3195 | 0.0763 | 0.0620 |
| Adjusted $R^2$ | 0.1486 | 0.2445 | -0.0260 | -0.0419 |
| F-statistic | 87.1507*** (df = 6; 1,724) | 115.5790*** (df = 7; 1,723) | 21.2564*** (df = 6; 1,544) | 17.0036*** (df = 6; 1,544) |

**Note**: The table depicts the four first differenced regressions of dynamic externalities on employment growth. T-statistics are estimated using clustered standard errors (reported in the parentheses). Ærø, Tønder, and Aabenraa are omitted from the data in Model III and IV due to no employment in several high- and low-tech industries. Significance levels are indicated by the asterisks with *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

## Appendix 18: Detailed Overview of Statistics Denmark's Standard Groupings of Industries

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| (1) | | | | **Landbrug, skovbrug og fiskeri** |
| | A | | | **Landbrug, skovbrug og fiskeri** |
| | | A | | **Landbrug, skovbrug og fiskeri** |
| | | | 01.00.0 | Landbrug og gartneri<br>01.11.00, 01.12.00, 01.13.00, 01.14.00, 01.15.00, 01.16.00, 01.19.00, 01.21.00, 01.22.00, 01.23.00, 01.24.00, 01.25.00, 01.26.00, 01.27.00, 01.28.00, 01.29.00, 01.30.00, 01.41.00, 01.42.00, 01.43.00, 01.44.00, 01.45.00, 01.46.10, 01.46.20, 01.47.00, 01.49.10, 01.49.20, 01.50.00, 01.61.00, 01.62.00, 01.63.00, 01.64.00, 01.70.00 |
| | | | 02.00.0 | Skovbrug<br>02.10.00, 02.20.00, 02.30.00, 02.40.00 |
| | | | 03.00.0 | Fiskeri<br>03.11.00, 03.12.00, 03.21.00, 03.22.00 |
| (2) | | | | **Industri, råstofindvinding og forsyningsvirksomhed** |
| | B | | | **Råstofindvinding** |
| | | B | | **Råstofindvinding** |
| | | | 06.00.0 | Indvinding af olie og gas<br>06.10.00, 06.20.00 |
| | | | 08.00.9 | Indvinding af grus og sten<br>05.10.00, 05.20.00, 07.10.00, 07.21.00, 07.29.00, 08.11.00, 08.12.00, 08.91.00, 08.92.00, 08.93.00, 08.99.00 |
| | | | 09.00.0 | Service til råstofindvinding<br>09.10.00, 09.90.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | C | | | **Industri** |
| | | CA | | **Føde-, drikke- og tobaksvareindustri** |
| | | | 10.00.1 | Slagterier<br>10.11.10, 10.11.90, 10.12.00, 10.13.00 |
| | | | 10.00.2 | Fiskeindustri<br>10.20.10, 10.20.20 |
| | | | 10.00.3 | Mejerier<br>10.51.00, 10.52.00 |
| | | | 10.00.4 | Bagerier, brødfabrikker mv.<br>10.61.00, 10.62.00, 10.71.10, 10.71.20, 10.72.00, 10.73.00 |
| | | | 10.00.5 | Anden fødevareindustri<br>10.31.00, 10.32.00, 10.39.00, 10.41.00, 10.42.00, 10.81.00,10.82.00, 10.83.00, 10.84.00, 10.85.00, 10.86.00, 10.89.00, 10.91.00, 10.92.00 |
| | | | 11.00.0 | Drikkevareindustri<br>11.01.00, 11.02.00, 11.03.00, 11.04.00, 11.05.00, 11.06.00, 11.07.00 |
| | | | 12.00.0 | Tobaksindustri<br>12.00.00 |
| | | CB | | **Tekstil- og læderindustri** |
| | | | 13.00.0 | Tekstilindustri<br>13.10.00, 13.20.00, 13.30.00, 13.91.00, 13.92.10, 13.92.20, 13.93.00, 13.94.00, 13.95.00, 13.96.00, 13.99.00 |
| | | | 14.00.0 | Beklædningsindustri<br>14.11.00, 14.12.00, 14.13.00, 14.14.00, 14.19.00, 14.20.00, 14.31.00, 14.39.00 |
| | | | 15.00.0 | Læder- og fodtøjsindustri<br>15.11.00, 15.12.00, 15.20.00 |
| | | CC | | **Træ- og papirindustri, trykkerier** |
| | | | 16.00.0 | Træindustri<br>16.10.00, 16.21.00, 16.22.00, 16.23.00, 16.24.00, 16.29.00 |
| | | | 17.00.0 | Papirindustri<br>17.11.00, 17.12.00, 17.21.00, 17.22.00, 17.23.00, 17.24.00, 17.29.00 |
| | | | 18.00.0 | Trykkerier mv.<br>18.11.00, 18.12.00, 18.13.00, 18.14.00, 18.20.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | | CD | | **Olieraffinaderier mv.** |
| | | | 19.00.0 | Olieraffinaderier mv.<br>19.10.00, 19.20.00 |
| | | CE | | **Kemisk industri** |
| | | | 20.00.1 | Fremst. af basiskemikalier<br>20.11.00, 20.12.00, 20.13.00, 20.14.00, 20.15.00, 20.16.00, 20.17.00, 20.20.00 |
| | | | 20.00.2 | Fremst. af maling og sæbe mv.<br>20.30.00, 20.41.00, 20.42.00, 20.51.00, 20.52.00, 20.53.00, 20.59.00, 20.60.00 |
| | | CF | | **Medicinalindustri** |
| | | | 21.00.0 | Medicinalindustri<br>21.10.00, 21.20.00 |
| | | CG | | **Plast-, glas- og betonindustri** |
| | | | 22.00.0 | Plast- og gummiindustri<br>22.11.00, 22.19.00, 22.21.00, 22.22.00, 22.23.00, 22.29.00 |
| | | | 23.00.1 | Glasindustri og keramisk industri<br>23.11.00, 23.12.00, 23.13.00, 23.14.00, 23.19.00, 23.20.00, 23.41.00, 23.42.00, 23.43.00, 23.44.00, 23.49.00 |
| | | | 23.00.2 | Betonindustri og teglværker<br>23.31.00, 23.32.00, 23.51.00, 23.52.00, 23.61.00, 23.62.00, 23.63.00, 23.64.00, 23.65.00, 23.69.00, 23.70.00, 23.91.00, 23.99.10, 23.99.90 |
| | | CH | | **Metalindustri** |
| | | | 24.00.0 | Fremst. af metal<br>24.10.00, 24.20.00, 24.31.00, 24.32.00, 24.33.00, 24.34.00, 24.41.00, 24.42.00, 24.43.00, 24.44.00, 24.45.00, 24.46.00, 24.51.00, 24.52.00, 24.53.00, 24.54.00 |
| | | | 25.00.0 | Metalvareindustri<br>25.11.00, 25.12.00, 25.21.00, 25.29.00, 25.30.00, 25.40.00, 25.50.00, 25.61.00, 25.62.00, 25.71.00, 25.72.00, 25.73.00, 25.91.00, 25.92.00, 25.93.00, 25.94.00, 25.99.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | | CI | | **Elektronikindustri** |
| | | | 26.00.1 | Fremst. af computere og kommunikationsudstyr mv.<br>26.11.00, 26.12.00, 26.20.00, 26.30.00, 26.40.00 |
| | | | 26.00.2 | Fremst. af andet elektronisk udstyr<br>26.51.00, 26.52.00, 26.60.10, 26.60.90, 26.70.00, 26.80.00 |
| | | CJ | | **Fremst. af elektrisk udstyr** |
| | | | 27.00.1 | Fremst. af elektriske motorer mv.<br>27.11.00, 27.12.00, 27.20.00 |
| | | | 27.00.2 | Fremst. af ledninger og kabler<br>27.31.00, 27.32.00, 27.33.00 |
| | | | 27.00.3 | Fremst. af husholdningsapparater, lamper mv.<br>27.40.00, 27.51.00, 27.52.00, 27.90.00 |
| | | CK | | **Maskinindustri** |
| | | | 28.00.1 | Fremst. af motorer, vindmøller og pumper<br>28.11.10, 28.11.90, 28.12.00, 28.13.00, 28.14.00, 28.15.00 |
| | | | 28.00.2 | Fremst. af andre maskiner<br>28.21.00, 28.22.00, 28.23.00, 28.24.00, 28.25.00, 28.29.00, 28.30.00, 28.41.00, 28.49.00, 28.91.00, 28.92.00, 28.93.00, 28.94.00, 28.95.00, 28.96.00, 28.99.00 |
| | | CL | | **Transportmiddelindustri** |
| | | | 29.00.0 | Fremst. af motorkøretøjer og dele hertil<br>29.10.00, 29.20.00, 29.31.00, 29.32.00 |
| | | | 30.00.0 | Fremst. af skibe og andre transportmidler<br>30.11.00, 30.12.00, 30.20.00, 30.30.00, 30.40.00, 30.91.00, 30.92.00, 30.99.00 |
| | | CM | | **Møbel og anden industri mv.** |
| | | | 31.00.0 | Møbelindustri<br>31.01.00, 31.02.00, 31.03.00, 31.09.00 |
| | | | 32.00.1 | Fremst. af medicinske instrumenter mv.<br>32.50.00 |
| | | | 32.00.2 | Legetøj og anden fremstillingsvirksomhed<br>32.11.00, 32.12.00, 32.13.00, 32.20.00, 32.30.00, 32.40.00, 32.91.00, 32.99.00 |
| | | | 33.00.0 | Reparation og installation af maskiner og udstyr<br>33.11.00, 33.12.00, 33.13.00, 33.14.00, 33.15.00, 33.16.00, 33.17.00, 33.19.00, 33.20.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | **D** | | | **Energiforsyning** |
| | | **D** | | **Energiforsyning** |
| | | | 35.00.1 | Elforsyning<br>35.11.00, 35.12.00, 35.13.00, 35.14.00 |
| | | | 35.00.2 | Gasforsyning<br>35.21.00, 35.22.00, 35.23.00 |
| | | | 35.00.3 | Varmeforsyning<br>35.30.00 |
| | **E** | | | **Vandforsyning og renovation** |
| | | **E** | | **Vandforsyning og renovation** |
| | | | 36.00.0 | Vandforsyning<br>36.00.00 |
| | | | 37.00.0 | Kloak- og rensningsanlæg<br>37.00.00 |
| | | | 38.00.0 | Renovation og genbrug<br>38.11.00, 38.12.00, 38.21.10, 38.21.20, 38.22.00, 38.31.00, 38.32.00 |
| | | | 39.00.0 | Rensning af jord og grundvand<br>39.00.00 |
| **(3)** | | | | **Bygge og anlæg** |
| | **F** | | | **Bygge og anlæg** |
| | | **F** | | **Bygge og anlæg** |
| | | | 41.00.0 | Byggeentreprenører<br>41.10.00, 41.20.00 |
| | | | 42.00.0 | Anlægsentreprenører<br>42.11.00, 42.12.00, 42.13.00, 42.21.00, 42.22.00, 42.91.00, 42.99.00 |
| | | | 43.00.1 | Bygningsinstallation<br>43.21.00, 43.22.00, 43.29.00 |
| | | | 43.00.2 | Bygningsfærdiggørelse<br>43.31.00, 43.32.00, 43.33.00, 43.34.10, 43.34.20, 43.39.00 |
| | | | 43.00.9 | Murere og anden specialiseret bygge- og anlægsvirksomhed samt forberedende byggepladsarbejde |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | | | | 43.11.00, 43.12.00, 43.13.00, 43.91.00, 43.99.10, 43.99.90 |
| **(4)** | | | | **Handel og transport mv.** |
| | G | | | **Handel** |
| | | G | | **Handel** |
| | | | 45.00.1 | Bilhandel<br>45.11.10, 45.11.20, 45.19.10, 45.19.20 |
| | | | 45.00.2 | Bilværksteder mv.<br>45.20.10, 45.20.20, 45.20.30, 45.20.40, 45.31.00, 45.32.00, 45.40.00 |
| | | | 46.00.1 | Agenturhandel<br>46.11.00, 46.12.00, 46.13.00, 46.14.00, 46.15.00, 46.16.00, 46.17.10, 46.17.90, 46.18.00, 46.19.00 |
| | | | 46.00.2 | Engrosh. med korn og foderstof<br>46.21.00, 46.22.00, 46.23.00, 46.24.00 |
| | | | 46.00.3 | Engrosh. med føde-, drikke- og tobaksvarer<br>46.31.00, 46.32.00, 46.33.00, 46.34.10, 46.34.20, 46.35.00, 46.36.00, 46.37.00, 46.38.10, 46.38.90, 46.39.00 |
| | | | 46.00.4 | Engrosh. med tekstiler og husholdningsudstyr<br>46.41.00, 46.42.10, 46.42.20, 46.43.10, 46.43.20, 46.43.30, 46.43.40, 46.43.50, 46.44.10, 46.44.20, 46.45.00, 46.46.10, 46.46.20, 46.47.00, 46.48.00, 46.49.10, 46.49.20, 46.49.30, 46.49.90 |
| | | | 46.00.5 | Engrosh. med it-udstyr<br>46.51.00, 46.52.10, 46.52.20 |
| | | | 46.00.6 | Engrosh. med andre maskiner<br>46.61.00, 46.62.00, 46.63.00, 46.64.00, 46.65.00, 46.66.00, 46.69.00 |
| | | | 46.00.7 | Anden engroshandel<br>46.71.00, 46.72.00, 46.73.10, 46.73.20, 46.74.00, 46.75.00, 46.76.00, 46.77.00, 46.90.00 |
| | | | 47.00.1 | Supermarkeder og varehuse mv.<br>47.11.10, 47.11.20, 47.11.30, 47.19.00 |
| | | | 47.00.2 | Specialbutikker med fødevarer<br>47.21.00, 47.22.00, 47.23.00, 47.24.00, 47.25.00, 47.26.00, 47.29.00 |
| | | | 47.00.3 | Tankstationer<br>47.30.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| | | | 47.00.4 | Detailh. med forbrugerelektronik<br>47.41.00, 47.42.00, 47.43.00 |
| | | | 47.00.5 | Detailh. med tekstiler og husholdningsudstyr mv.<br>47.51.00, 47.52.10, 47.52.20, 47.53.00, 47.54.00, 47.59.10, 47.59.20, 47.59.30, 47.59.40, 47.59.90, 47.73.00, 47.74.00, 47.75.00, 47.76.10, 47.76.20, 47.76.30, 47.77.00, 47.78.10, 47.78.20, 47.78.30, 47.78.40, 47.78.90, 47.79.00 |
| | | | 47.00.6 | Detailh. med kultur- og fritidsprodukter<br>47.61.00, 47.62.00, 47.63.00, 47.64.10, 47.64.20, 47.64.30, 47.65.00 |
| | | | 47.00.7 | Detailh. med beklædning og fodtøj<br>47.71.10, 47.71.20, 47.72.10, 47.72.20 |
| | | | 47.00.8 | Internethandel, postordre mv.<br>47.81.00, 47.82.00, 47.89.00, 47.91.11, 47.91.12, 47.91.13, 47.91.14, 47.91.15, 47.91.16, 47.91.17, 47.91.19, 47.91.20, 47.99.00 |
| | H | | | **Transport** |
| | | H | | **Transport** |
| | | | 49.00.1 | Regional- og fjerntog<br>49.10.00, 49.20.00 |
| | | | 49.00.2 | Lokaltog, bus og taxi mv.<br>49.31.10, 49.31.20, 49.32.00, 49.39.10, 49.39.20 |
| | | | 49.00.3 | Fragtvognmænd og rørtransport<br>49.41.00, 49.42.00, 49.50.00 |
| | | | 50.00.0 | Skibsfart<br>50.10.00, 50.20.00, 50.30.00, 50.40.00 |
| | | | 51.00.0 | Luftfart<br>51.10.10, 51.10.20, 51.21.00, 51.22.00 |
| | | | 52.00.0 | Hjælpevirksomhed til transport<br>52.10.00, 52.21.10, 52.21.20, 52.21.30, 52.22.10, 52.22.20, 52.23.00, 52.24.00, 52.29.10, 52.29.20, 52.29.90 |
| | | | 53.00.0 | Post og kurertjeneste<br>53.10.00, 53.20.00 |
| | I | | | **Hoteller og restauranter** |
| | | I | | **Hoteller og restauranter** |
| | | | 55.00.0 | Hoteller mv.<br>55.10.10, 55.10.20, 55.20.00, 55.30.00, 55.90.00 |
| | | | 56.00.0 | Restauranter<br>56.10.10, 56.10.20, 56.21.00, 56.29.00, 56.30.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
|---|---|---|---|---|
| (5) | | | | **Information og kommunikation** |
| | J | | | **Information og kommunikation** |
| | | JA | | **Forlag, tv og radio** |
| | | | 58.00.1 | Forlag<br>58.11.00, 58.12.00, 58.13.00, 58.14.10, 58.14.20, 58.19.00 |
| | | | 58.00.2 | Udgivelse af computerspil og anden software<br>58.21.00, 58.29.00 |
| | | | 59.00.0 | Produktion af film, tv og musik mv.<br>59.11.10, 59.11.20, 59.12.00, 59.13.00, 59.14.00, 59.20.00 |
| | | | 60.00.0 | Radio- og tv-stationer<br>60.10.00, 60.20.00 |
| | | JB | | **Telekommunikation** |
| | | | 61.00.0 | Telekommunikation<br>61.10.00, 61.20.00, 61.30.00, 61.90.00 |
| | | JC | | **It- og informationstjenester** |
| | | | 62.00.0 | It-konsulenter mv.<br>62.01.00, 62.02.00, 62.03.00, 62.09.00 |
| | | | 63.00.0 | Informationstjenester<br>63.11.00, 63.12.00, 63.91.00, 63.99.00 |
| (6) | | | | **Finansiering og forsikring** |
| | K | | | **Finansiering og forsikring** |
| | | K | | **Finansiering og forsikring** |
| | | | 64.00.1 | Pengeinstitutter<br>64.11.00, 64.19.00 |
| | | | 64.00.2 | Kreditforeninger mv.<br>64.20.10, 64.20.20, 64.20.30, 64.30.10, 64.30.20, 64.30.30, 64.30.40, 64.91.00, 64.92.10, 64.92.20, 64.92.30, 64.92.40, 64.99.00 |
| | | | 65.00.0 | Forsikring og pension<br>65.11.00, 65.12.00, 65.20.00, 65.30.10, 65.30.20 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
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| | | | 66.00.0 | Finansiel service<br>66.11.00, 66.12.00, 66.19.00, 66.21.00, 66.22.00, 66.29.00, 66.30.00 |
| **(7)** | | | | **Ejendomshandel og udlejning** |
| | **L** | | | **Ejendomshandel og udlejning** |
| | | **L** | | **Ejendomshandel og udlejning** |
| | | | 68.00.1 | Ejendomsmæglere mv.<br>68.10.00, 68.31.10, 68.31.20, 68.32.10, 68.32.20 |
| | | | 68.00.2 | Boligudlejning<br>68.20.10, 68.20.20, 68.20.30 |
| | | | 68.00.3 | Udlejning af erhvervsejendomme<br>68.20.40 |
| **(8)** | | | | **Erhvervsservice** |
| | **M** | | | **Videnservice** |
| | | **MA** | | **Rådgivning mv.** |
| | | | 69.00.1 | Advokatvirksomhed<br>69.10.00 |
| | | | 69.00.2 | Revision og bogføring<br>69.20.00 |
| | | | 70.00.0 | Virksomhedskonsulenter<br>70.10.10, 70.10.20, 70.21.00, 70.22.00 |
| | | | 71.00.0 | Arkitekter og rådgivende ingeniører<br>71.11.00, 71.12.10, 71.12.20, 71.12.30, 71.12.40, 71.12.90, 71.20.10, 71.20.20, 71.20.90 |
| | | **MB** | | **Forskning og udvikling** |
| | | | 72.00.0 | Forskning og udvikling<br>72.11.00, 72.19.00, 72.20.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
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| | | **MC** | | **Reklame og øvrig erhvervsservice** |
| | | | 73.00.0 | Reklame- og analysebureauer<br>73.11.10, 73.11.90, 73.12.00, 73.20.00 |
| | | | 74.00.0 | Anden videnservice<br>74.10.10, 74.10.20, 74.10.30, 74.20.00, 74.30.00, 74.90.10, 74.90.90 |
| | | | 75.00.0 | Dyrlæger<br>75.00.00 |
| | **N** | | | **Rejsebureauer, rengøring og anden operationel service** |
| | | **N** | | **Rejsebureauer, rengøring og anden operationel service** |
| | | | 77.00.0 | Udlejning og leasing af materiel<br>77.11.00, 77.12.00, 77.21.00, 77.22.00, 77.29.00, 77.31.00, 77.32.00, 77.33.00, 77.34.00, 77.35.00, 77.39.00, 77.40.00 |
| | | | 78.00.0 | Arbejdsformidling og vikarbureauer<br>78.10.00, 78.20.00, 78.30.00 |
| | | | 79.00.0 | Rejsebureauer<br>79.11.00, 79.12.00, 79.90.00 |
| | | | 80.00.0 | Vagt og sikkerhedstjeneste<br>80.10.00, 80.20.00, 80.30.00 |
| | | | 81.00.0 | Ejendomsservice, rengøring og anlægsgartnere<br>81.10.00, 81.21.00, 81.22.10, 81.22.20, 81.22.90, 81.29.00, 81.30.00 |
| | | | 82.00.0 | Anden operationel service<br>82.11.00, 82.19.00, 82.20.00, 82.30.00, 82.91.00, 82.92.00, 82.99.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
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| (9) | | | | **Offentlig administration, undervisning og sundhed** |
| | O | | | **Offentlig administration, forsvar og politi** |
| | | **O** | | **Offentlig administration, forsvar og politi** |
| | | | 84.00.1 | Offentlig administration<br>84.11.00, 84.12.00, 84.13.00, 84.30.00 |
| | | | 84.00.2 | Forsvar, politi og retsvæsen mv.<br>84.21.00, 84.22.00, 84.23.00, 84.24.00, 84.25.00 |
| | P | | | **Undervisning** |
| | | **P** | | **Undervisning** |
| | | | 85.00.1 | Grundskoler<br>85.10.00, 85.20.10, 85.20.20 |
| | | | 85.00.2 | Gymnasier og erhvervsfaglige skoler<br>85.31.10, 85.31.20, 85.32.00 |
| | | | 85.00.3 | Videregående uddannelsesinstitutioner<br>85.41.00, 85.42.00 |
| | | | 85.00.4 | Voksenundervisning mv.<br>85.51.00, 85.52.00, 85.53.00, 85.59.00, 85.60.00 |
| | Q | | | **Sundhed og socialvæsen** |
| | | **QA** | | **Sundhedsvæsen** |
| | | | 86.00.1 | Hospitaler<br>86.10.00 |
| | | | 86.00.2 | Læger, tandlæger mv.<br>86.21.00, 86.22.00, 86.23.00, 86.90.10, 86.90.20, 86.90.30, 86.90.40, 86.90.90 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
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| | | QB | | **Sociale institutioner** |
| | | | 87.00.0 | Plejehjem mv.<br>87.10.10, 87.10.20, 87.20.10, 87.20.20, 87.30.10, 87.30.20, 87.90.10, 87.90.20, 87.90.90 |
| | | | 88.00.0 | Daginstitutioner og dagcentre mv.<br>88.10.10, 88.10.20, 88.10.30, 88.91.10, 88.91.20, 88.91.30, 88.91.40, 88.91.50, 88.91.60, 88.99.10, 88.99.20, 88.99.90 |
| **(10)** | | | | **Kultur, fritid og anden service** |
| | **R** | | | **Kultur og fritid** |
| | | **R** | | **Kultur og fritid** |
| | | | 90.00.0 | Teater, musik og kunst<br>90.01.10, 90.01.20, 90.02.00, 90.03.00, 90.04.00 |
| | | | 91.00.0 | Biblioteker, museer mv.<br>91.01.10, 91.01.20, 91.02.00, 91.03.00, 91.04.00 |
| | | | 92.00.0 | Lotteri og andet spil<br>92.00.00 |
| | | | 93.00.1 | Sport<br>93.11.00, 93.12.00, 93.13.00, 93.19.00, |
| | | | 93.00.2 | Forlystelsesparker og andre fritidsaktiviteter<br>93.21.00, 93.29.10, 93.29.90 |
| | **S** | | | **Andre serviceydelser mv.** |
| | | **S** | | **Andre serviceydelser mv.** |
| | | | 94.00.0 | Organisationer og foreninger<br>94.11.00, 94.12.00, 94.20.00, 94.91.00, 94.92.00, 94.99.00 |
| | | | 95.00.0 | Reparation af husholdningsudstyr<br>95.11.00, 95.12.00, 95.21.00, 95.22.00, 95.23.00, 95.24.00, 95.25.00, 95.29.00 |
| | | | 96.00.0 | Frisører, vaskerier og andre serviceydelser<br>96.01.10, 96.01.20, 96.02.10, 96.02.20, 96.03.00, 96.04.00, 96.09.00 |

| 10-Std.gr. | 19-Std.gr. | 36-Std.gr. | 127-Std.gr. | |
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| | | | | **Private husholdninger med ansat medhjælp** |
| | | | | **Private husholdninger med ansat medhjælp** |
| | | | 97.00.0 | Private husholdninger med ansat medhjælp<br>97.00.00, 98.10.00, 98.20.00 |
| | | | | **Internationale organisationer og ambassader** |
| | | | | **Internationale organisationer og ambassader** |
| | | | 99.00.0 | Internationale organisationer og ambassader<br>99.00.00 |
| **(11)** | **X**[16] | | | **Uoplyst aktivitet** |
| | | **X** | | **Uoplyst aktivitet** |
| | | | 99.99.9 | Uoplyst aktivitet<br>99.99.99 |

**Source**: From Statistics Denmark (Torma, Simbold, Sørensen, Madsen, & Skjelbo, 2015).